How can I improve the skills of writing balanced chemical equations using chemical symbols and formulas for 2nd year 10 integrated natural science extension trainees? The case of Woldia College of Teachers Education

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Abstract

The main objective of this study was to improve writing skills of balanced chemical equations using chemical symbols of elements and formulas for ten 2nd Year integrated Natural Science extension trainees. Participants were selected using a purpose sampling method. The tools used in data collection were observation, document analysis, questionnaire, test, and interview. The data collected by these tools were analyzed by qualitative and quantitative analysis methods according to their characteristics. According to this study, the participants had very little understanding of the symbolic language, which is very important for learning chemistry. Therefore, to solve this problem and to fill the gaps, the researcher had to set special tutorial and counseling programs to improve their skills. After the plan was implemented, all the study participants' skills in chemical symbol identification, writing formulas, and balanced chemical equation improved except for one trainee.

Introduction

Background of the study

It is an indisputable fact that education is the basis of a country's political, social, and economic development. If education is planned and accomplished well, it will have the potential to bring about the desired change. However, if the teaching process is flawed in one way or another, the benefits will not be complete. For example, when a good curriculum is developed and it comes to school, it is difficult to imagine the quality of the education provided if there is a problem with the interaction between the administration of the educational institution, the teacher, and the student (Hailu D et al., 2010) and (Negassa, O. (2014)

If we want to improve the quality of education, we must pay special attention to learning. Studies

Showed that research and quality of education must go hand in hand. The reality is different. The

role of research for quality of education in higher education is less than expected (Shirani Bidabadi et al., 2016).

Although the government of Ethiopia is now taking various steps to maintain the quality of education, I have noticed in my experience that there was a problem with trainees' education, especially in the natural science department, which was a potential obstacle to the desired quality of education. Of these, natural science students in particular for chemistry subject, they did not attend classes well and they did not score good results.

Chemistry is one of the major disciplines of science. Knowledge of chemistry is very important in solving problems in our daily lives like cooking food, washing clothes, etc. As a result, a student with a poor background in chemistry in secondary school will face a problem continuing his or her education in a higher institution. Meaning that the future results in chemistry will be lower. Students with a low level of chemistry did not seem to have learned the language of chemistry. For example, they did not understand the basic rules of chemistry necessary to write symbols, chemical formulas (Khurshid et al., 2017).

Therefore, chemistry education has its language, which makes it different from other subjects. This means that since chemistry and chemical symbols are inextricably linked, the key to teaching chemistry is to rely heavily on identifying the symbolic language that is the subject of instruction. Ignorance of this communication makes it very difficult to teach chemistry (J. D. Bradley1 and E. Steenberg2, n.d.).

Thus, the inability to identify the chemical symbols and formulas makes it difficult to classify substances into elements, compounds, and mixtures. This problem appeared during the courses that I have taught for my students namely Basic Natural Science One (BNSC101), Basic natural science two (BNSC102), and General Chemistry one (Chem211).

Nowadays we have about 118 natural and man-made chemical elements in the periodic table. It is believed that our trainees when they came to our college they are already learned about the most common metals and non-metal elements in their primary and secondary schools. But the reality was controversial to this. That is they have a low level of writing chemical symbols, formulas, and writing chemical equations. This is because the symbolic representation of elements serves as a language of communication for chemistry.

So chemistry education has its language. Thus, knowing and understanding the most common elements is a priority for learning chemistry. As our trainees are at the college level, the role of the teacher is very important for trainees in identifying the symbols of elements, using their symbols to write the formula and using them to write balanced chemical equations, as a result, to achieve good results. Thus, for trainees to understand this lesson properly, first, the trainees must learn symbols of the elements, then using symbols how to write formulas, and finally to improve their ability how to write chemical equations.

The main problem that I have encountered at Woldia College of Teachers Education for the past 10 years was because my trainees did not identify chemicals symbols of elements, they could not understand properties of a substance, valence number, difficult to distinguish between monoatomic ions (Na^{+}, Mg^{+2}, Al^{+3}, Cl^{-1}, etc) and polyatomic ions (CO_3^{-2}, OH^{-1}, NO_3^{-1} SO_4^{-2}), formation of chemical bonding, writing the balanced chemical equation, chemical composition of compounds, and so on. So, I found the problem was worse.

In the first week of the first semester, the course that I thought was general chemistry one, I assigned individual work to each trainee to classify elements like metal and non-metal, to identify compounds and mixtures. When they asked the oral question, a few trainees could not express their ideas. In the classroom, the researcher was encouraged them to write and to speak as much as they knew. But their interest was low. In this case, they were asked to write the formula for compounds, and what they wrote in their notebooks was vague and they could not explain it themselves.

As natural science trainees, while they were in this situation, they could not learn the courses without being able to identify the most common elements, different compounds, or molecules. Then, I advised them to stay with their side and for each trainee, I gave them a notebook with a detailed explanation to fill in this gap.

In another session, I gave them classwork that was focused on symbols of elements. For those few trainees that were with critical problems, the researcher has assisted them in writing formulas and asking questions without being afraid, and lastly, the researcher advised them their problem could improve if they tried their best.

Accordingly, they were not happy to show what they had written in their notebooks, because it was not clear. In particular, some of the elements were found to be difficult for them to write their exact symbols because their symbolic representation was not taken from their English name.

To solve these problems the researcher gave them, ways of giving symbols of elements for all trainees for the sake of practice at their home. In the next session, I tried to sit with them in the classroom to see their progress. But those trainees with critical problems, I could not find a way to teach the course and I realized that I could not teach all the trainees properly.

The course that I gave for them was focused on starting from identifying elements to writing the chemical equation, which made it difficult for them to learn properly if their current problems were not improved. So, along with teaching the course, I decided to help those trainees with critical problems. This is because I believed that the formal teaching and learning process did not solve trainees' problems, as a result, they need special time and place to solve their critical problems.

Realizing this, the researcher was compelled to do this action research to improve the skills of the trainees who were having trouble writing symbols, formulas and to improve the trainees' ability to write balanced chemical equations.

Statement of the problem

In my experience in teaching chemistry, I have noticed that the most recurrent incidence of difficulties in trainees was the problem of identifying names of common elements, formulas, and chemical equations. This problem was seen in 1^{st} to 3^{rd}-year trainees, but it was a very serious problem especially for 1st and 2nd-year trainees.

Particularly, during the courses that offered to the trainees, Basic Natural Science One (BNSC101), Basic Natural Science Two (BNSC102), Basic Chemistry One (Chem201), and General Chemistry One (Chem211), I faced difficulties in implementing the objectives of the courses when giving oral questions, class works, individual assignments, group assignments, and various tests.

In addition to this, trainees with this problem were not able to work on their own, so it was often a problem to try to copy from their friends or took notes during exams. Therefore, for those who were in critical problems of trainees, improving the skills of writing symbols of elements, formulas, and chemical equations will reduce the problem and increase their self-confidence.

Studies had shown that having a basic concept about chemistry, understanding the rules, can lead to learning chemistry courses without difficulty. Particularly, beginner trainees faced problems in writing symbols of elements, formulas, chemical equations, and stoichiometric calculations (Geleta, 2014).

Candidates who came to our college often have this problem. Many candidates were not want to join the natural science department. Because they thought that science (chemistry, biology, and physics) education was difficult. One of the most difficult things to learn chemistry was the lack of a language of chemistry skills. This means a lack of the ability to write chemical symbols, formulas, and chemical equations (Khurshid, M.et al., 2017)

As our trainees were at the college level, it was a serious problem to deliver the course properly, especially for those trainees with a critical problem, because chemistry courses they were studying include in addition to writing chemical symbols of elements or formulas, it comprises chemical reactions, chemical bonds, properties of compounds, and so on.

In general, for those trainees with critical problems, the researcher in the classroom was observed that there was a general lack of attention paid to the courses they taught.

This problem was very serious, especially for extension or evening students. To further refine the problem, trainees with critical problems were taking special exams concerning writing chemical symbols, formulas, and chemical equations. But they scored very low results. Therefore, based on my class observation and their exam results inspired me to conduct this action research to fill the gap.

Based on the stated problem the study attempted to provide answers to the following basic research questions.

What is the reason for trainees' inability to identify the language of chemistry needed to learn chemistry properly?

What is the cause of trainees' inability to classify chemical symbols properly?

What cause of the trainee's low understanding of writing valance and subscripts?

What are the major contributing factors that influence the skills of trainees to write accurately chemical formulas using chemical symbols?

How can I improve trainees' ability to write chemical equations using chemical formulas?

Objectives of the study

General Objective

Improving writing skills of balanced chemical equations using chemical symbols of elements and formulas for ten 2nd Year integrated Natural Science extension trainees.

Specific Objective

- To identify the reason for trainees' inability to identify the language of chemistry needed to learn chemistry properly.
- To identify the cause of trainees' inability to classify chemical symbols properly.
- To find out the trainee's low understanding of writing valance and subscripts.
- To examine major contributing factors that influence the skills of trainees to write accurately chemical formulas using chemical symbols.
- To assess the improvement of trainees' ability to write chemical equations using chemical formulas.

Significance of the study

Trainees are more likely to know the chemical symbols of elements

Trainees can develop writing chemical formulas using symbols of elements

Help trainees understand how to write valance and subscripts

Help trainees to develop skills in writing balanced chemical equations using symbols and formulas.

Theoretical And Conceptual Explanations Of Related Works

Introduction

It is believed that learning is not a repetitive process of going to and from school and it is only possible to make a change of behavior and knowledge within the grade level (Negassa, 2014).

In today's world of education, it is important to have a clear understanding of what students are learning, as it is a major tool for improving one's interests. If education is to be effective, it is important to hold students accountable (Kasa, 2016).

In general, many factors influence students attending their class learning properly. The most common are economic and social problems. For example, a student may find it difficult to manage his or her life without adequate food, clothing, and shelter.

They did not positively understand their environment. Thus, in one way or another, it is difficult for a student with such a problem to attend their class properly. (Hailu Dinka et al., 2010) stated that family poverty or economic hardship forces children to earn a living instead of going to school. This prevents them from focusing on their studies. According to the study, students with financial problems did not learn the lessons on time, did not do their homework, teamwork, assignments, and exams on time.

Challenges writing chemical symbols and formulas

Most Problems in learning chemistry are caused by a lack of a language of chemistry skills.

Thus, understanding valence, the concept of poly-atomic ions, mono-atomic ions and molecules, and the formation of chemical formulas are based on the student's knowledge of chemical bonds. In chemical bonding, the concepts are not simple to understand easily, so that only students that have skills can apply their knowledge and becomes more effective (Edomwonyi-Otu & Avaa, 2011) and (Tsaparlis, G. 2018)

Names and symbols of chemical elements are the languages of chemistry. Currently, there are 118 elements in the modern periodic table. All 118 elements have their names and symbols.

Once the student has learned the names and symbols of elements, it will be easier to write chemical formulas and chemical equations. The symbols of elements are abbreviated from their names and are used to distinguish elements from one another. The names of the elements are usually derived from their English names, German, Latin or Greek words, the name of the place of their origin, the name of the people they have researched. Therefore, this chemical symbol is used to represent the full names of the element (Geleta, 2014).

Problems in writing chemical equations

A chemical equation is the symbolic representation of a chemical reaction in the form of symbols and formulae, wherein the reactant entities are given on the left-hand side and the product entities on the right-hand side.

For example, the chemical equation is given below, A and B represent reactants, C and D are the products. The small letter a, b, c, d are the coefficients used to balance the equation. x, y, z, q are subscripts.

$$aA_x + bB_y \longrightarrow cC_z + dD_q$$

Due to a lack of understanding of the above concepts, our trainees in the college have critical problems writing balanced chemical equations (Tsaparlis, G. 2018).

Research Methodology

A descriptive survey research design, which comprises qualitative and semi-quantitative methods was applied. Because it enables the researcher to get current information about the trainees.

3.1. Sample Size and Sampling Technique

As a focus of this study, 10 trainees were selected from the 38 ^{2nd} year integrated natural science extension trainees and the selection was purposive sampling technique applied. Tests and observations were used primarily to select participants. Because it enables the researcher to solve the critical problems of trainees about chemical symbols of elements, chemical formulae, and chemical equations, which are the language of chemistry.

3.2. Participants of the study

10 trainees and 5 chemistry teachers were participated in identifying the problems and participating in the process to solve the problem and to evaluate the results. Purposely, all 5 chemistry teachers who thought different chemistry courses have participated in the study.

Table 1
Statistical data of the study participants

Study participants					
Trainees			Teachers		
Male	Female	Total	Male	Female	Total
5	5	10	5	-	5

3.3. Data Gathering Instruments and Procedures

The study employed mainly qualitative and quantitative data collection tools. The data collection tools selected for this study were document analysis, test, observation, written questionnaire, and interview. Accordingly, their implementation was as follows.

Observations. The researcher has used it as a collection of tools, because it was used for collecting information about trainees' overall classroom activities, including their involvement in learning chemistry, their ability to classify elements as metal and non-metal, their ability to give names of chemical symbols, their ability to write formulas and equations, their attempts to ask questions. **Test.** The researcher was used for data collection tool to determine their ability to write chemical symbols, formulas, and chemical equations and to compare their progress after the implementation.

Document Analysis- The researcher was used it to gather previous background information about the study participants. These include, grade 10th chemistry results and in the college-level basic natural science courses (BNSC101 and BNSC102) with their grade point were included.

This data gathering tool was included because the researcher believed that the participants' problems were critical and existed for a long period.

Questionnaire (Open and close ended)- The researcher has used a written questionnaire for trainees to identify their family background, address, and cause of the problem, as well as to identify their ability to write chemical symbols, formulas, and chemical equations in a closed-ended questionnaire, and they were asked in an open-ended questionnaire to suggest solutions. These data collection tools have also been developed by a researcher based on a variety of essays and have been reviewed by my colleagues and implemented.

Interview

This data collecting tool was applied for the sake of collecting detailed information about trainees' critical problems. Based on this, 5 questions were prepared that require a detailed explanation of the chemical symbols, formulas, subscripts, coefficient numbers, and arrows that included in balanced chemical equations. 4 interview questions also were prepared for teachers and asked to them give their opinions concerning trainees' critical problems.

Method of Data Analysis

The data collected from teachers and trainees through questionnaires, observation, and interviews were analyzed using tables and descriptive analysis methods. The information obtained from classroom observation was explained in detail using a qualitative data analysis method. Test results were analyzed quantitatively using percentages, graphs, and tables.

Results And Discussion

4.1. Data analysis Obtained through document

The data obtained from the document was presented below.

Table 2
Previous information about the study participants obtained from documents.

No.	Study participants code	Grade 10 chemistry result	Basic natural science I (BNSC101) result		Basic natural science II (BNSC102) result	
			100%		100%	
1	02	C	59	C	58	C
2	04	C	70	B	52.25	C
3	06	C	47	D	41.75	D
4	08	C	61	C	50.75	C
5	10	C	50	C	44	D
6	12	C	68	C	54	C
7	14	C	70	B	64	C
8	16	C	54	C	57	C
9	18	C	52	C	61.75	C
10	20	C	58	C	52	C
Source- Registrar Office.						

As shown in Table2, the previous history of the participants showed that their grade 10th chemistry results did not exceed C, as well as in our college they scored lower results in basic natural science courses (BNSC101 & BNSC102).

As indicated in Table 2, as the study participants moved from basic natural science I to basic natural science II courses, the results of all the study participants were lowered. No progressive change appeared. When trainees became familiar with the college environment, they were expected to perform better as they move from the first semester to the second semester. But the reverse was true. This indicated that the study participants had critical problems with chemistry subject in the first place, and this was the reason why the current course, general chemistry I, were not effective.

4.2. Data analysis Obtained through questionnaire

Pre-survey general information obtained through a written questionnaire

Table 3
General information of the study participants

Options		Number of respondents	Percent/%/
Residential address	Rural	10	100
	Town		
Family work situation	Business		
	Agriculture	10	100
	Government worker		
	Other		
Within a month how many days you were absent from the class?	Frequently		
	Sometimes	3	30
	Never	7	70
When you were learning chemistry in the class, who was covers most of the time?	Teachers	6	60
	Trainees	1	10
	Equally	3	30
Is there any suitable study area or room in your home?	Yes	4	40
	No	6	60
I know exactly the names and chemical symbols of more than 10 common elements	Agree	2	20
	Disagree	5	50
	I doubt it	3	30
Are you familiar with the names and chemical symbols of common elements? If your answer is no, What is your reason? If your answer is yes, leave it.	Lack of family follow-up	1	10
	Lack of teachers follow-up	1	10
	Lack of personal effort	5	50
	Problem of seeing the subject harder	4	40

As shown in Table 3, all participants (100%) live in rural areas and the livelihoods of their families depend on agriculture.

As indicated in Table 3, for the question, within a month how many days you were absent from the class, 30% of trainees responded "sometimes" and 70% of trainees responded "never" meaning they had never missed their class.

Regarding time coverage in the classroom, as shown in Table3, 60% of trainees revealed that most of the time covered by teacher's presentation, 30% of trainees responded that student and teacher's participation being equal and 10% of trainees responded that classroom participation covered by students.

Concerning suitable study areas, as indicated in Table3, 60% of trainees responded "no" meaning that most trainees had no suitable study area in their home. Similarly, 40% of trainees revealed that "yes" meaning that those trainees were had a suitable study area in their home.

Regarding knowing the names and chemical symbols of elements, 50% of trainees replied "disagree", 30% of trainees revealed "I doubt it" and only 20% of trainees replied, "agree". This indicated that most trainees were not known the way to give names and assigning chemical symbols. 30% of trainees were not sure about chemical symbols and their naming system.

Concerning trainee's familiarity with names of common elements and their symbolic representation, as shown in Table3, 40% of trainees revealed "problem of seeing the subject harder", 50% of the respondents replied "lack of personal effort" and the remaining 10% of trainees responded, "lack of family follow up".

The general information in Table 3, showed that the classroom was usually occupied by the teacher, meaning the role of the students was low. Similarly, half of the study participants did not identify chemical symbols of common elements. This could hurt their academic performance. Because symbols of chemical elements are the language of chemistry subjects, trainees faced critical problems to learn chemistry.

4.3. Symbols of elements, chemical formula and chemical equation Preliminary analysis of test results

Table 4
Pre-test results of the focus group trainees'.

Study participants code	sex	Tasks performed					
		Symbol identification 25%	Metal and non-metal classification 25%	Valance and subscript identification 22%	Formula writing skills 25%	Chemical equation writing skills 3%	Total (100%)
02	M	0	0	0	0	0	0
04	M	0	0	0	2	0	2
06	M	3	0	0	0	0	3
08	M	3	0	0	4	0	7
10	F	7	0	0	0	0	7
12	F	8	2	0	2	0	12
14	M	9	0	2	1	0	12
16	F	12	0	0	0	0	12
18	F	11	4	2	1	0	18
20	F	11	5	7	2	0	25

As indicated in Table 4, the study participants were asked to identify symbols of elements from 25%. From this, code 02 and 04 scored zero, code 06 and 08 scored 3(12%), code 10 scored 7(28%), code 12 scored 8(32%), code 14 scored 9(32%), code 16 scored 12(48%) and code 18 & 20 scored 11(44). For classification of elements as metals and non-metals from 25%, the study participants scored as follows. Code 02, 04, 06, 08, 10, and 16 scored zero. Code 12 scored 2(8%), code 18 scored 4(16%) and code 20 scored 5(20). This indicated that the study participants had difficulty in identifying the elements properly.

As shown in Table 4, concerning valance and subscript, study participants were asked from 22%. From this, code 02, 04, 06, 08, 10, 12, 16 scored zero. Code 14 & 18 scored 2(8%) and code 20 scored 7(28%).

Concerning writing chemical formula, 25% of test results of study participants were as follows. Code 02, 06, 10, 16 scored zero. Code 04, 12, and 20 scored 2 (10%). Code 08 scored 4(20%) and code 14, 18 scored 1(5).

Regarding writing a chemical equation, all the participants scored zero from 3% meaning that their skill to write chemical equation were low.

In general the study participants main problems observed in the classroom

• Partially read symbols of elements orally but they could not write in text.

• Not ready to learn properly in the classroom

• Not volunteer to write symbols of elements in their notebook and on the blackboard

• The chemical formula, symbols of elements they wrote in their notebook or blackboard were unreadable (unclear, unknown).

• Difficult to define the meaning of Valence and subscript

• Ignorance of the difference between symbols of elements, formulas, and chemical equations

• Never tried to write a balanced chemical equation

• When they wrote the chemical equation, they did not know the reactant and the product.

4.4. Analysis of the data Obtained through Interview.

The trainees were asked 5 questions that contain names of the chemical symbols, formulas, names of the molecules, and several molecules, subscript number, and coefficient number, the meaning of arrow, reactant, and product. They replied as follows

From elementary to high school, there was no adequate basis, not practicing the symbols of common elements, not trying to write formulas using chemical symbols; we faced a problem to learn different chemistry courses at the college level because we were not familiar with writing balanced chemical equation.

An interview made with 4 chemistry teachers about the skills of study participants on writing symbols, formulas, and balanced chemical equations they responded that:-

Since the symbols of elements used for the language of chemistry are represented by the English alphabet, our trainees did not identify common elements because they had difficulty distinguishing the English alphabet in the first place. Many trainees did not know how the names of elements are taken. Also, they did not know how to write symbols, meaning that the first letter should be written in capital letters and the second letter should be written in small letters. As a result, they were not interested to learn chemistry. To support trainees with such problems to learn chemistry, first-year courses, such as in basic natural science I, the way to write symbols of elements must incorporate.

4.5. Strategies to alleviate the problem

10 integrated natural science 2nd-year extension trainees have participated in this study. Their critical problem was identifying the symbols of elements used as a language of communication for chemistry. Based on this some strategies were designed to minimize the problem of writing and naming symbols, formulas, valence, subscripts, and chemical equations.

1. An adequate understanding was created and encouraged, a series of advice was provided for all of the study participants by the researcher.

2. Modern periodic tables were prepared in Amharic and English for each of them to practice writing symbols. The researcher also monitored.

3. A special tutorial program was developed lasts for one month for all study participants to prepare ready to took the course without a problem and the researcher has continuously assisted them in filling the gaps, starting from identifying and naming common elements to chemical equations.

4. All study participants were practiced continuously by writing symbols, formulae on their notebook and blackboard. Those who made progress were encouraged, and others were advised to improve and learn from their friends.

5. In the classroom, the study participants were seated in front of the teacher to reduce their fears, and they were encouraged to ask questions about what they did not understand.

6. A comprehensive note on the basic concepts of chemistry has been prepared for a group and individual study, which includes a variety of chemical symbols, formulas/molecules, and chemical equations.

Table 5
A table showing the action plan

No.	Tasks performed Regarding activities that can develop a chemical equation writing skills	The executive body	Time	Input
1.	• Awareness was created about the importance of the study • Advices has been given how they could improve their results. • In order to understand atomic symbols, they practiced how their abbreviations were assigned.	Researcher and study participants	November 20–25/2020	Paper
1. 2 2.	• They were completed the written questionnaire for the preliminary survey and then interviewed. • Their ability to write symbols, formulae and chemical equations was identified by giving short tests. • Modern periodic tables were prepared in Amharic and English for individuals to practice writing symbols. The researcher also monitored. • The researcher were monitored for their time usage	Researcher and study participants	November 25 to December 10/2020	Paper
3.	• A special tutorial program was developed lasts for one month for all study participants to teach them the course without problem and the researcher was continuously assisted them in filling the gaps, starting from identifying and naming common elements to chemical equations. • The change was monitored by a preparing check list • They were practiced about valence number meaning that sum of the positive and negative ions in a chemical formula must be zero. • They were instructed to write a balanced chemical equation • Continuous advising was given for all study participants	Researcher and study participants	December 10 to January 15/2020	Paper
4.	• To identify their gaps and improvements after the awareness has been created; a test was given again and the difference was recorded. • Background information of the study were identified using questionnaire and interview • Next, useful information was collected • They were motivated by giving continues advising	Researcher and study participants	January10-20/2020	Paper
	• Finally, we reviewed the process with my colleagues and trainees together.	Researcher, study participants and teachers		

Strategies Implementation, Evaluation And Summary

5.1. Strategies

As shown in Chapter Four Data Analysis, the participants in this study had critical problems in writing chemical symbols, formulae, valence, subscripts, and balanced chemical equations. So, Strategies have been implemented to simplify these related problems.

Although these overlapping problems seemed to be difficult to solve at once, we agreed with the study participants to develop their skills in writing symbols, formulas, and chemical equations in one month.

To address this critical problem, the researcher gave more attention to those chemical symbols of common elements, particularly, their name was not taken from their English names, such as sodium (Na), potassium (K), and lead (Pb). Using a special tutorial program the study participants were taught the classification of elements as metals and non-metals, identification of valence numbers, subscripts, and based on this concept trainees tried to write chemical formulas and balanced chemical equations.

To develop their efforts and increase their participation in the classroom, the researcher was given a variety of exercises to study on their own.

5.1.2. Modern periodic table in Amharic and English was prepared for study participants

The common elements in the modern periodic table have been distributed to each of them to identify their full names and symbols, and it was being monitored.

This means that whenever they came to tutor, they were with their notebooks and the periodic table to evaluate their changes in each day. They reflected on how the elements were symbolized from their English name, how they were derived from the Greek word in the classroom in each tutoring program. More attention was given during the discussion for assigning symbols, which means the first English letter should always be written in capital letters for all elements, the second English letter should always be written in small letters, and other related ideas. For example, magnesium is an English name, and its symbol is written as Mg, Copper is derived from its Latin name that is Cuprum, and its symbol is written as Cu.

5.1.3 Worksheet for individuals

Worksheets on chemical symbols, formulas, chemical equations, and ions were prepared and given to each of them, and the researcher was in touch with them on weekly programs. This worksheet also contained the ways how to write balanced chemical equations, names of mono-atomic ions and poly-atomic ions. They were practiced in class and their private homes. Those participants who were serious problems in classifying the most common elements as metals and non-metals took more time to fill their gaps.

5.1.4 Practice by preparing a special tutorial session

As shown in Table 5, of the Action Plan, the study participants were assigned two hours a week from December 10 to January 15, 2020, with a special tutorial program. During this session, how to write symbols, how to write chemical formulae, subscripts, valence, balanced chemical equations were practiced in their notebook and on the blackboard, and corrections were made in the process.

At the time of the tutorial program, special attention was given to elements their names taken from the English name, for example, Calcium, symbolized as Ca Chlorine, symbolized as Cl Magnesium, symbolized as Mg, and their names taken from Greek or Latin words like Potassium = from Latin Kalium = K, Sodium from Latin Natrium = Na, Mercury from Greek Hydrargyrum = Hg.

The participants, who were able to identify the symbols of the elements, were taught in the classroom to write the chemical formula and developed their ability to write a balanced chemical equation based on a chemical formula.

It was realized that the focus of the study was improving the skills of writing symbols, formulas, and chemical equations, the researcher advised them continuously to improve their critical problems by asking questions at any time without hesitation.

The trainees realized that the sum of the positive and negative ions in a chemical formula should be zero, and they practiced in their notebooks to formulate chemical symbols, formulas, and balanced chemical equations. As a result, they have shown significant change. My colleagues also supported this study by reviewing trainees 'changes and reviewing the trainees' tests.

5.2. After implementation

After awareness was created, the study participants were tested again to identify their weaknesses and improvements, which are presented in the following table.

Table 6
Post-test results of the focus group trainees'

Study participants code	sex	Tasks performed					
		Symbol identification 25%	Metal and non-metal classification 25%	Valence and subscript identification 22%	Formula writing skills 25%	Chemical equation writing skills 3%	Total (100%)
02	M	15	3	16	5	0.5	39.5
04	M	22	0	15	18	2.5	57.5
06	M	20	4	19	14	1	58
08	M	22	12	21	16	1	72
10	F	23	18	14	10.5	2.5	68
12	F	18	16	15	15	2	66
14	M	25	10	18	18	1.5	72.5
16	F	25	12	20	15	3	75
18	F	24	11	21	19	2.5	77.5
20	F	25	18	21	19	2	84

As shown in Table 6, above, code 02 symbol identification scored 15 out of 25%, metal and non-metal classification scored 3 out of 25, valence number and subscript identification scored 16 out of 22, formula writing scored 5 out of 25% and chemical equation scored 0.5 out of 3% with a total of 39.5%. It showed a slight improvement from 0–39.5% from 100% and showed that writing skills of chemical formula and chemical equation had not improved. It cannot also classify common elements like metal and non-metals.

Before action Code, 04 was scored 2% from 100% but after action scored 57.5%, showed good improvement. For example, symbol identification scored 22 out of 25%, this result was a very good improvement. Metal and non-metal classification scored zero out of 25%. No improvement in this case. Valence number and subscript identification scored 15 out of 22%, formula writing scored 18 out of 25% and chemical equations scored 2.5 out of 3%.

As shown in Table 6, Code 06 had scored 3% before action and improved to 58% after action. In detail, symbol identification before action scored only 3 out of 25% and after-action scored 20 out of 25%, showed very good improvement. Metal and non-metal classification scored 4 out of 25%, only slightly improved. Valence number and subscript identification scored 19 out of 22%, formula writing scored 14 out of 25% and chemical equation scored 1 out of 3%. In this cause showed very good improvement.

When analyzing the results of code 08 before and after action, the identification of common elements from 25% increased from 3 to 22, and metal and non-metal classification from 25% zero to 12. Valence and subscript identification from 22% increased from 0 to 21. Formula writing from 25% increased from 4 to 16 and chemical equation from 3% increased from 0 to 1. In general, this trainee before action scored 7 out of 100% and after-action scored 72 out of 100%. This was a remarkable change.

As shown in Table 6, above, code 10 symbol identification scored 23 out of 25%, metal and non-metal classification scored 18 out of 25, valence number and subscript identification scored 14 out of 22, formula writing scored 10.5 out of 25% and chemical equation scored 2.5 out of 3% with a total of 68%. It showed a very good improvement from 7–68% from 100%.

As indicated in Table 6, above, code 12 symbol identification scored 18 out of 25%, metal and non-metal classification scored 16 out of 25, valence number and subscript identification scored 15 out of 22, formula writing scored 15 out of 25% and chemical equation scored 2 out of 3% with a total of 66%. It showed good improvement from 12–66% from 100%.

Code 14 had a significant change in symbol identification from 25% scored 9 before action, 25 after action. The classification of elements as metal and non-metal from 25% scored 0 before action, 10 after action. Valence number and subscript identification improved from 2 to 18 from 22%. Formula writing improved from 1 to 25 from 25% and chemical equation had increased from 0 to 1.5 from 3%. Overall, showed improvement from 12–72.5%.

As shown in Table 6 above, Code 16 had a significant change in symbol identification from 12 to 25 out of 25%. In the classification of elements as metal and non-metal, it showed a slight change from 0 to 12 out of 25%. Valence number and subscript identification showed great improvement from 0 to 20 out of 22%. Formula writing improved from 0 to 15 from 25% and the chemical equation increased from 0 to 3 out of 3%. Overall, 12% before action and 75% after action. This result was a significant change.

As shown in Table 6 above, code 18 had scored a significant result for identification of symbols 11 before action and 24 after action from 25%. The classification of elements as metal and non-metal had increased from 4 to 11 from 25%. The change in valence number and subscript identification before and after the action increased significantly from 2 to 21 from 22% respectively. Formula writing increased from 1 to 19 from 25%, and chemical equations improved from 0 to 2.5 from 3%. Overall, it has improved significantly from 18–77.5%.

As shown in Table 6 above, code 20 scored an excellent score of 25 out of 25% in symbol identification. The classification of elements as metal and non-metal had increased from 5 to 18 from 25%. This indicated good progress. Valence number and subscript identification before and after the action increased significantly from 7 to 21 out of 22%. Formula writing increased from 2 to 18 out of 25%, and the chemical equation improved from 0 to 2.5 from 3%. Overall, significantly improved from 25–84%.

Table 7
Comparison of pre-test and post-test results

Study participants code	**Sex**	**Symbol identification 25%**		**Metal and non-metal classification 25%**		**Valence and subscript 22%**		**Formula writing skill 25%**		**Chemical equation writing skill 3%**		**Total (100%)**	
		Before action	**After action**	**Before action**	**After action**	**Before action**	**After action**	**Before action**	**After action**	**Before action**	**After action**	**Before action**	**After action**
02	M	0	15	0	3	0	16	0	5	0	0.5	0	39.5
04	M	0	22	0	0	0	15	2	18	0	2.5	2	57.5
06	M	3	20	0	4	0	19	0	14	0	1	3	58
08	M	3	22	0	12	0	21	4	16	0	1	7	72
10	F	7	23	0	18	0	14	0	10.5	0	2.5	7	68
12	F	8	18	2	16	0	15	2	15	0	2	12	66
14	M	9	25	0	10	2	18	1	18	0	1.5	12	72.5
16	F	12	25	0	12	0	20	0	15	0	3	12	75
18	F	11	24	4	11	2	21	1	19	0	2.5	18	77.5
20	F	11	25	5	18	7	21	2	18	0	2	25	84

As shown in Table 7 above, before the tutorial, pre-test results of the study were very low compared to post-test results in all activities. Thus, the study participants' average score before the tutor assistance was 9.8, and the total score after the tutor's assistance was 67.

The results of each activity are described as follows.

Table 8
Comparison of study participants with improved and unaltered results in each task

Activities	**Trainees who did not improve**		**Trainees improved results**	
	Number	**%**	**Number**	**%**
Ability to identify common elements/symbols	0	0%	10	100%
Ability to classify metal and non-metal	4	40%	6	60%
Skills to write subscript, valence	0	0%	10	100%
Skills to write formulae	2	20%	8	80%
Skills to write balanced chemical equation	3	30%	7	70%

As shown in Table 8 above, all of the 10 participants in the study showed the improved result in most activities.

Post-implementation results showed that 6 out of 10 participants were improved their ability to classify common elements like metal and non-metal but 4 (40%) trainees scored low. Concerning their ability to identify common elements/symbols and writing subscript and valence numbers, all participant's results were improved. Their skills to write formulae, 8 out of 10 participants were scored improved results. Similarly, their skills to write a balanced chemical equation, 7 out of 10 participants were scored improved results but only 3 out of 10 trainees did not improve their results.

Graph1. The study participants who achieved improved and unaltered results in each activities.

Table 9
Comparison of study participants who scored less than half of the test results before and after the implementation of each activities.

Activities	**Participants who scored less than half of the test results**			
	Before Action		**After Action**	
	Number	**%**	**Number**	**%**
Ability to identify common elements/symbols	10	100%	0	0%
Ability to classify metal and non-metal	10	100%	7	70%
Skills to write subscript, valence	10	100%	0	0%
Skills to write formulae	10	100%	2	20%
Skills to write balanced chemical equation	10	100%	4	40%

As shown in Table 9, Concerning their ability to identify common elements/symbols, all participants were scored less than half before the action but after implementation of the action, all participants were scored more than half. Study participants' ability to classify common elements like metal and non-metal all participants before action was scored less than half and after-action implemented only 7 out of 10 participants were scored less than half. Concerning their skills to write subscript, valence, before action was implemented all participants were scored less than half but after action implementation, all participants scored more than half. Regarding their skills to write formulae, all participants were scored less than half before action implementation but only 2 out of 10 participants were scored less than half after the implementation of the action. Similarly, Skills to write a balanced chemical equation, before action implementation all participants were scored below half and after implementation of the action, only 4 out of 10 scored below half.

Graph 2. Study participants scored less than half of the test results before and after each action implementation.

Table 10
Comparison of study participants who scored greater than half of the test results before and after the implementation of each activities.

Activities	Participants who scored greater than half of the test results			
	Before Action		After Action	
	Number	%	Number	%
Ability to identify common elements/symbols	0	0%	10	100%
Ability to classify metal and non-metal	0	0%	3	30%
Skills to write subscript, valence	0	0%	10	100%
Skills to write formulae	0	0%	8	80%
Skills to write balanced chemical equation	0	0%	6	60%

As shown in Table 10, Concerning their ability to identify common elements/symbols, all participants were scored less than half before the action but after implementation of the action, all participants were scored more than half. Ability to classify common elements like metal and non-metal all participants before action was scored less than half and after-action implemented only 3 out of 10 participants were scored more than half. Concerning their skills to write subscript, valence, before action was implemented all participants were scored less than half but after action implementation, all participants scored more than half. Regarding their skills to write formulae, all participants were scored less than half before action implementation but only 8 out of 10 participants were scored more than half after the implementation of the action. Similarly, Skills to write a balanced chemical equation, before action implementation all participants were scored below half and after implementation of the action, only 6 out of 10 scored more than half.

Graph 3. Study participants scored more than half of the test results before and after each action implementation.

5.3. Evaluation

In this study, after the implementation of the action plan, except for one trainee, all focus group trainees' skills of writing chemical symbols of common elements were improved. In particular, four trainees have correctly identified the most common elements.

On the other hand, classifying common elements as metal and non-metal, codes 10, 12, and 20 scored more than 16 out of 25%, showed good improvement. As a result, their average score was 17.33. Concerning subscript and valence distinction out of 22%, all participants scored more than 14 points. Their average score was 18. In this cause, all focus group trainees' showed good improvement.

Evaluation of their ability to write chemical formulas using symbols of common elements revealed an average score of 15.9 out of 25%, except for one participant. Regarding their ability to write a balanced chemical equation, 3 out of 10 participants revealed significant improvement, while 7 participants showed low improvement.

5.4. Problems encountered

1. One of the study participants was scored low grades due to his problems and little attention paid to the subject. He had trouble attending a special tutorial program. This problem could not be solved.

2. Since the study Participants were an extension, there was a tendency to be absent from the tutorial, however, except for one trainee the problem was resolved through serious consultation.

3. There was a lack of a sense of ownership on performing different activities in their home and the classroom. Similarly, the problem was resolved through discussion.

What needs to be done next?

As a chemistry teacher, for those natural science trainees, before graduating from college, I will work hard to address the basics of chemistry education, such as chemical symbols of common elements, writing formulae, valence, subscripts, and skills to write the balanced chemical equation.

The strengths of the study

The positive things that were observed in the trainees using the developed implementation strategies.

1. Focus group trainees have developed a sense of motivation for the course they were learning, motivation to ask what they didn't understand, try to answer questions, and try to work with their friends.

2. Improved their practice of taking useful ideas in their notebooks

3. Focus group trainees were prepared to work without fear for their different tests, classwork, group assignments are given.

4. Overall, the results of all participants were improved except for one participant

Weak side of the study

From 10 focus group trainees, one participate was not improved his result.

5.5. Summary

Chemistry has its language, so it sets it apart from other subjects. This means that since chemistry and chemical symbols are inextricably linked, the key to teaching chemistry is to rely heavily on identifying the symbolic language that is the subject of instruction. Ignorance of this communication makes it very difficult to teach chemistry (J. D. Bradley1 and E. Steenberg2, n.d.).

This means that chemistry has its language. Thus, it can be said that knowing and understanding the elements is a priority for learning chemistry.

As students at the college level, the role of the teacher is very important in identifying the symbols of elements, in formulating their representations, in enabling them to write balanced chemical equations and to achieve good results.

Primarily, their critical problems of participants were lack of understanding symbols of elements, lack of identifying valence and subscripts when writing chemical formula, lack of identification of elements with variable valence when writing their formula: For example, unable to identify the difference between FeO (Iron (II) and Fe_2O_3 Iron (III), difficulties to distinguish between monoatomic ion (Na^+, Mg^{+2}, Al^{+3}, Cl^{-1}, etc.) polyatomic ions like ($CO_3{}^{-2}$, OH^{-1}, $NO_3{}^{-1}$ $SO_4{}^{-2}$).

Secondly, the reason why the study participants were affected by this problem, the lack of personal effort (50%) and the inability to identify symbols of common elements that are used as the language of chemistry education (50%).

What did I learn from this study?

In this study, I learned many experiences. This has helped me to deal with the problems I face in my future work. The main ones are

1. Since Chemistry has its language of communication, if I make sure they have this kind of problem, I have learned that along with the course I am learning, their desire to learn can be improved by identifying their basic problems, especially those that are the language of communication for chemistry.

2. In conducting this research, I found that the strategies I used to fill in the gaps for students were effective because they changed their grades.

3. I have learned that trainees with special problems can improve their interest in learning and achievement if we can help them with their problems and develop special tutoring programs, run various discussions and provide counseling services, their learning needs and outcomes can be improved.

4. I have learned that action research requires patience, far-sightedness, and cooperation.

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Declarations

Declaration of Conflicting Interests

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Figures

Figure 1

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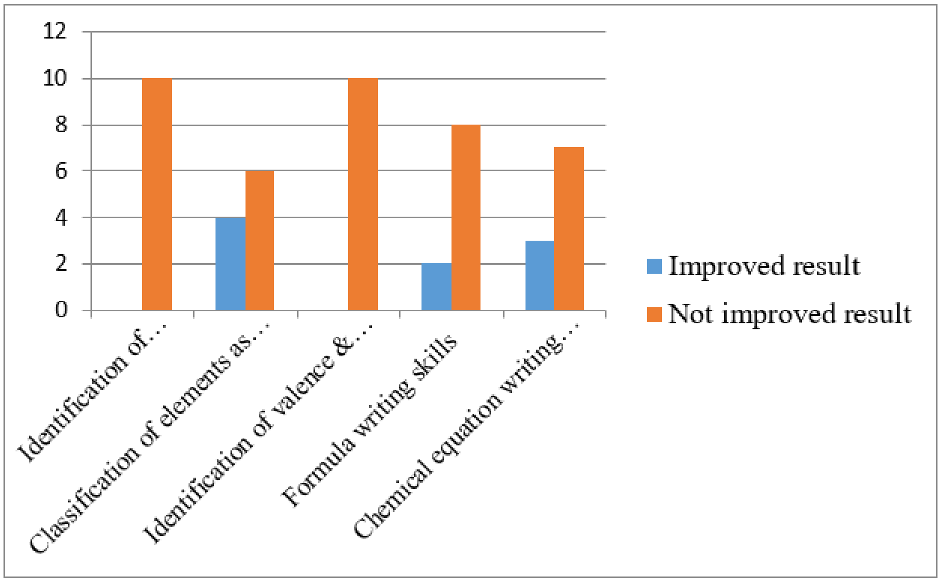

Figure 2

Graph1. The study participants who achieved improved and unaltered results in each activities.

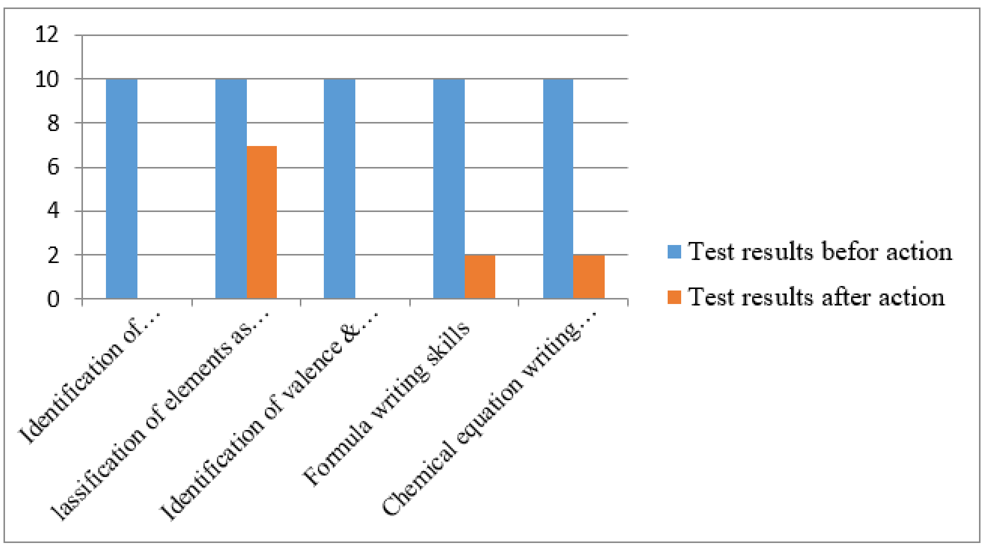

Figure 3

Graph 2. Study participants scored less than half of the test results before and after each action implementation.

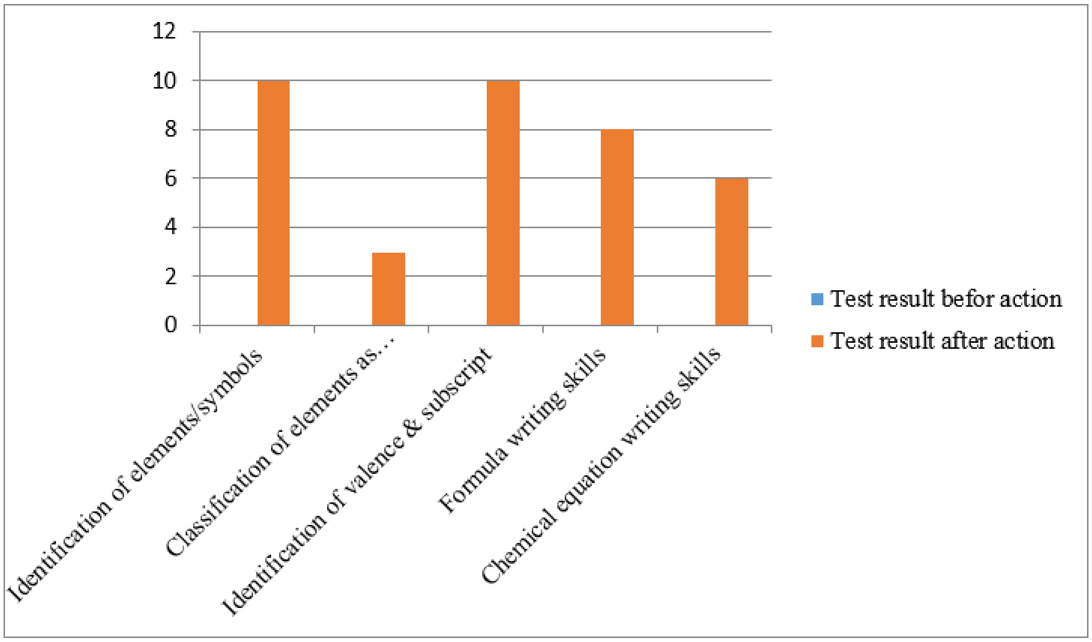

Figure 4

Graph 3. Study participants scored more than half of the test results before and after each action implementation.

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