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GUIDELINES FOR AUTHORS
Dear AJCE Communities,

Welcome to the 4th year’s first issue of AJCE. This issue reports, in addition to its regular research works, the successful launch of the first African Conference on Chemistry Education in Africa (ACRICE-1) held in Addis Ababa on 5-7 December 2013 at a time when African governments and the people at large were celebrating the 50th Anniversary of the Organization of African Unity (OAU) presently known as the African Union (AU) since 2002.

ACRICE is intended as a platform for understanding and enriching education for preparation of African citizens who are able to deal with local and global challenges. To that end, educators and researchers at all levels were invited to share vital knowledge and strategies for teaching and learning in culturally responsive ways. It is believed that the maiden conference was a great success. Read more on this from the reports of Prof. John Bradley (South Africa) and Prof. Jan Apotheker (The Netherlands).

The Editorial Team of AJCE wishes you a happy and prosperous 2014.
ETHIOPIAN STUDENTS' ACHIEVEMENT CHALLENGES IN SCIENCE EDUCATION: IMPLICATIONS TO POLICY FORMULATION

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ABSTRACT
The purpose of this study was to investigate challenges on students’ academic achievement in science education across selected preparatory schools of Ethiopia. The participants were students, teachers and principals from three regions and nine schools. The participants of the study were 801 students and 118 science teachers from preparatory schools. A mixed case study research and multiple case research method were employed. Purposive and stratified sampling methods were used. The study examined the data generated through questionnaires, academic achievement tests, interviews and document analysis. Regression, Path-analysis, ANOVA, T-test, correlation, standard deviation and other statistical tools were used for data analysis. The results showed that strong relationship existed between science achievement and school resource, family income, family occupation, family education, and teachers’ factors. Moreover, this study showed that the teaching-learning process of science education in Ethiopian schools failed to meet the requirements of policy expectation. It is recommended that due consideration should be paid to improving school conditions, teachers’ capacity, and student-related factors for effective implementation of science curriculum. [AJCE 4(1), January 2014]
INTRODUCTION

In our modern world, science occupies an ever-expanding place in our everyday life and is the basis for development. It is essential for increasing science literacy and cultivating a generation of scientists(1). Therefore, it is evident that education with science is the major component that contributes to the level of prosperity, welfare and security of a nation. In this sense, science education is believed to serve as the foundation of technological development, and it is a key factor in economic growth (2).

It is as a result of the recognition given to physical sciences in the development of the individual and the nation that these subjects are considered core - subjects among the natural sciences and other science- related courses in the Ethiopian education system. The inclusion of physics and chemistry as core subjects in science in the secondary school calls for the need to teach them effectively. Therefore, in this modern society, education in general, science education in particular is not only a dominant factor for the formation of citizens and their complete realization as humans, but it is also emerging as a strategic means with key importance for the competitive global economy.

Furthermore, like any other developing country, Ethiopia needs rapid improvement of science education and appears to have been prepared to resolve issues of development in science and technology through its education and training policy. To make this practical, the policy provides for a 70:30 admission ratio in tertiary institutions in favor of science and technology by Ministry of Education (3).

However, the implementation process of science education is limited in Ethiopian schools. For instance, students in Ethiopia generally perform poorly in science subjects (4). The
The main factors that contribute to the poor performance of students in science may include problems associated with attitude, methods, teachers’ capacity and resources.

To this end, a basic question that this study puts forward is: ‘To what extent are Ethiopian preparatory schools (grades 11 and 12) ready to meet these policy expectations from different perspectives such as students’ readiness, teachers’ capacity and provisions of materials and human resources based on student academic achievement in general?’

THEORETICAL FRAMEWORK

The theory used as basis for this study was constructivist. Particularly, the two aspects of constructivist theory, that is, individual constructivist theory and social constructivist theory where used. There are some proponents of individual constructivist theory (5-8). According to these groups of advocators knowledge is considered to be mainly an individual’s construct. Social and cultural phenomena are also personal constructs.

On the other hand, social constructivist theory scholars such as (9-11) and others advocate social construction of knowledge. According to these groups knowledge is mainly a social construct. Learners construct their knowledge through interactions with teachers, other learners, materials and observing and exploring things. Learning in general and academic achievement in particular occurs in a social context and that much of what is learned is gained through observation. In the view of these authors, individual, social, environmental, cultural and material factors play roles in human learning and should be given due consideration.

The implication here is that both theories are equally necessary if learning is to be understood more fully. From this perspective the researcher has chosen to study learning in this study from both the individual and socio cultural perspectives. The assumption here concerns the
view that individual’s on-going functioning (achievement in the case of this study), cognitive behavioral, and environmental factors influence one another in a bidirectional, reciprocal fashion. The study explored those aspects of knowledge to determine their possible roles in the achievement of the students, that is, to test those theories.

PURPOSE, RESEARCH QUESTIONS AND METHODOLOGY OF THE STUDY

The purpose of this study was to assess academic achievement challenges of students in science education in Ethiopian preparatory schools (grades 11 and 12) in three administrative regions (Amhara, Oromia and SNNPR) by assessing students’ national examinations and current achievements in science. To meet these objectives, the following basic research questions were formulated:

1. What did Ethiopia preparatory schools students’ science education achievements look like?
   1.1. To what extent Ethiopian students achieved in science subjects in national examination in the past?
   1.2. To what extent do Ethiopian students achieve in science in standard tests?
   1.3. To what extent do students’ achievements vary across grade levels, regions, schools, sexes, mother tongue and residences?

2. What are the academic achievement challenges in science education of Ethiopian preparatory schools?
   2.1 To what extent do academic achievement challenges in science education vary across regions, sex and residences?
2.2 Do Students’ achievements in science correlate to academic achievement challenges in science?

2.3 Which of the challenges predict student academic achievement more?

3. What are the possible implications of the developed model for improving student academic achievement in science and quality of education in Ethiopia?

The subjects of the study were science students and science teachers. The data were mainly gathered through questionnaires, observations and interviews. The mixed approach was employed as research method. Document analysis was also made so as to substantiate these instruments. The data obtained were analyzed through the use of percentages, mean values; grand mean values, correlation coefficient, standard deviations, T-test, ANOVA, regression analysis, and path analysis. The analysis of the data has yielded the following major findings.

RESULTS AND DISCUSSIONS

This section provided answers to the research questions raised earlier in the study. The results are presented below.

Students’ academic achievement in science education

The grand mean achievements were 49.51% in national examinations and 44.47% in standard tests in science for the study group. This scores were less than the expected average score (50% by the Education and Training Policy) of Ethiopia. They were not only low but also significantly different from this expected value and were deteriorating too. The results of the one-sample T-test showed that the mean differences of the academic achievement test results for
the two tests for both grades were significantly different from the standard value (50%) at 95% confidence interval or at p< 0.05 level of significance (p=0.00). The mean differences were negative (mean difference=-5.53) for both standard tests. This indicated that the students’ academic achievement in standard test was below expectation of the policy. These findings are in line with Fensham (12).

Furthermore, their academic achievement in science did vary across their regions, and mother tongues. For instance, the total mean result achievements were 44.78%, 42.84%, 45.36% for Oromia, Amhara and SNNP regions respectively. The ANOVA test calculated for these regional differences revealed that the difference in science achievement among regions (846.96 or .65%) was much less than the differences in science achievement among individual students (129188.20 or 99.35%) in the same region. Therefore, there were significant differences in science achievement within the students of the three regions individually, not as a region which indicated that there were no differences among regions in their science achievement.

However, this finding implies that a participating region in a curriculum implementation study is likely to open up for diversity in visions, alternatives, promoting critical discussions, offering new ideas for experimentation, and above all, learning from others. Curriculum implementation studies thus enable a region to compare the similarities as well as the differences between related activities carried out in various regional contexts. This may offer a better understanding of the lessons learnt or drawn from policy implementation and education sector improvement strategies adopted by other regions.

On the other hand, students’ achievements in science do vary across their grade levels, schools, residences and sexes. For instance, the overall science achievement for grade 11 was 40.30% and that of grade 12 was 48.48% which indicated that grade 12 students perform better
in this particular study. The results of the independent sample T-test also showed that the mean difference between grade 11 and 12 students was significant at p< 0.05 (t=-9.58, p=0.00). The mean differences was negative (mean difference=-6.51) when test from grade 11 to grade 12.

Similarly, the overall academic achievement in science for male was 47.58% and for female was 39.70%. In all the cases, the mean scores of female were less than the mean scores of males. The mean differences were positive when we compare the results of male students with those of their female counterparts. That means males have scored higher than female students in those tests. This finding clearly supports the established fact that gender differences exist in science achievement (13). The results of the independent sample T-test also showed that the mean difference between male and female students was significant at p< 0.05 (p=.00) and t=11.17. Evidently, boys achieved mean scores that were higher by 8.44% than the mean scores achieved by girls.

Moreover, the overall science academic achievement for urban background and rural background students were 45.23% and 44.09% respectively, and the result of T-test showed that these differences in academic achievement of science between urban background and rural background students were significant statistically at p<.05 (p=.024) and at t=799.

Generally, the results of the study showed that the academic achievements of students do vary across regions, residences, across grade levels, sexes and schools. Such differences could be due to proper coverage of courses, better and proper qualification of teachers, better school facilities, proper school administration or differences in the way the students were educated beginning from the lower grades for each particular course. So the regional states can benefits from experience sharing to improve academic achievement of students in science and other courses.
Besides the above explanations, the results of this study beg the question of what could have gone wrong with the students to achieve such low achievement. To this end, in theoretical framework of this study, from constructivist perspective several basic assumptions about academic achievement of students’ were explained. One assumption concerns the view that individual’s on-going performance, personal factor, and environmental factors influence one another in a bidirectional, reciprocal fashion. That is, a person's on-going performance (academic achievement in the case of this study) is a product of a continuous interaction between cognitive behavior and contextual factors. The results of this study have investigated contextual challenges such as students’ related challenges, teachers’ related challenges, school related challenges and family related challenges. The study explored those challenges to determine their possible roles in the performance of the students, that is, to test the theory explained in theoretical framework of the study. For these purposes the contextual variables and thier influences on academic achievement were treated in the following subsections.

**Challenges on academic achievement in science education**

**A. Students’ attitudes toward science**

There were five categories under which attitudes of students were treated. These were: a) development of interest in science and science related activities, b) accepting of scientific enquiry as a way of thought, c) the enjoyment of science learning experience, d) development of interest in pursuing a career in science and science related work, and e) manifestation of favorable attitudes toward science and scientists. Accordingly, the grand mean for the first, second, third, fourth, and fifth categories were 2.36, 2.64, 2.62, 4.00, and 1.85 on a five-point scale.
These results indicated that students were not interested, not accepted scientific thoughts as a way of life, do not enjoy science, but develop interest to pursuing a career in science and did not manifest favorable attitudes toward science. Even though the respondents showed positive responses to one of the categories (develop interest to pursuing career in science) and the total mean for grade 12 was 2.71, that of grade 11 was 2.67 and total grand mean scale of the group on attitude scale was 2.69, the findings of this study showed that the respondents have developed negative attitudes toward science and scientists. The majority of students in preparatory schools feel that science is hard and difficult to them. Hence, they have no positive feeling toward the content of science curriculum, confirming other studies (14).

Furthermore, students’ attitudes toward science did vary across their grade levels, residences, regions, sexes, schools and mother tongue. For instance, the grand mean for the first, second, third, fourth, and fifth categories attitudes and the total mean attitudes were 2.70, 3.10, 3.08, 4.44, 2.02, 3.07 and 1.83, 1.90, 1.91, 3.32, 1.58, 2.11 on a five-point scale for males and females respectively. Even though these results indicated that students were not interested, not accept scientific thoughts as a way of life, do not enjoyed science, but develop interest to pursuing a career in science and do not manifested favorable attitudes toward science, males had more positive attitudes toward science. This study showed that boys have more positive attitudes toward science than girls.

B. Students’ academic self-concept of Science

This part deals with students’ academic self-concepts as science learners in relation to sub-categories of academic self-concept: Self-efficacy, intrinsic value and test anxiety.
Accordingly, the grand mean for the first, second and third categories were 2.83, 3.12, and 2.39 on a five-point scale.

These results indicated that students were not involved in learning science by their own sake and a belief in their own abilities, but they belief in the value of the task and they have an uncomfortable feeling of nervousness or worry about exams. Even though the respondents showed positive responses to one of the categories (belief in the value of the task)) the total grand mean scale of the group on academic self-concept scale was 2.78 and it showed that the respondents of this study have developed negative academic self-concept of science about their abilities. The majority of students in preparatory schools feel that they are incapable to perform science. Hence, they have negative academic self-concept of science about their abilities.

Moreover, this study showed that there were significant differences in academic self-concept of students in science between the two sexes. There was a mean difference between boys and girls in their academic self-concept of science and science learning in each category of academic self-concept. The overall results for academic self-concept students have about themselves were 2.9 (mean value for boys) and 2.59 (mean value for girls). These results imply that boys were more confident in their academic abilities than girls. Independent sample T-test showed that there was difference in variance for mean scores of males and female students in their academic self-concept. The difference was significant statistically at t=11.54 and p<0.05 (p=.00) significant level.

In the same way, the study showed that there were differences between students of different residences in their academic self-concept in science and science learning. The academic self-concept of urban background students (mean value=2.82) was in a better position than rural background students (mean value=2.76). The implication is that urban background area students
perceive themselves as better at science than rural background students. However, the T-test showed this difference was not statistically significant.

C. Students’ learning strategies in science education

This study analyzed the self-regulated learning strategies of students in science learning by categorizing the issues into two categories. These categories were cognitive learning strategies and meta-cognitive learning strategies. In the first category it is intended to measure the cognitive self-regulated learning strategies students used in learning science by measuring activities that can be measured directly from the responses given by students in the questionnaires and interview responses.

The aggregate mean= 2.44 on a five-point scale for this sub-category showed that students do not make appropriate use of these learning strategies to learn science. Similar to the first category, the grand mean of this category=2.35 showed that the respondents lacked appropriate meta-cognitive self-learning strategies in their science learning. The grand mean for all the categories 2.39 again showed that respondent students lack appropriate learning strategies to learn science which leads to achieving less in science. Supporting this finding different cognitive strategies such as rehearsal, elaboration, and organizational strategies have been found to foster active cognitive engagement in learning and result in higher levels of academic achievement (15).

Even though the majority of students lack appropriate learning strategies to learn science, their degree of usage of different learning strategies varies depending on their regions, sexes, residences and other factors. For instance, there were differences among the two sexes in using self-regulated learning strategies. The mean value for use of cognitive self-regulated learning
strategies for science learning was 2.80 for males and 1.86 for females and the mean for the use of self-regulated meta-cognitive learning strategies in science learning was 2.69 for male and 1.82 for female students. In overall use of self-regulated learning strategies, the mean value was 2.75 for males and 1.85 for females.

This showed that the mean differences were positive when we compare the male results with females’ results. This means that males used self-regulated learning strategies in science learning more than girls. The results of the independent sample T-test showed that the mean difference between male and female students was significant at p< 0.05. Therefore, in this study, boys were more strategic in their science learning than girls.

SUMMARY AND RECOMMENDATIONS

This study has shown that the Ethiopian schools seem unsuccessful in their efforts to improve the teaching learning of science and students’ science achievement. These conclusions are in line with Temechegn (16) that science education in general and chemistry teaching in particular in Ethiopia lack appropriate teaching process and curricular content for the target group of learners. The main factors that were believed to contribute to the poor academic achievement of students in science include: students’ attitudes toward science, students learning strategies, academic self-concept of students, teachers’ capacity, and ineffective teaching methods, scarcity of human and material resources, and family low income, and large family size.

As findings of this study have indicated, challenges in science education vary, to some extent, from school to school. They also vary from region to region. Moreover, the study indicated that most of our preparatory schools tend to have problems in providing quality
education. Typically, many schools have large class sizes, in some cases as many as eighty students, with few possibilities of meaningful group or individual work and few opportunities for direct contact with teachers; most of the schools experienced high rates of science teacher turnover and consequently lack of continuity in instructional delivery in follow up process; and shortage of science teachers is also a common problem observed in most of the schools. All schools in this study experienced, in one way or another, unsatisfactory teaching conditions. In particular, according to the respondents as cause of teacher’s low motivation, the schools seem to be characterized by constraints such as relatively low salaries, whose real value has been eroded over time.

The situation is even critical, for those teachers who teach many classes for many hours within the two shifts of their working hours; the teaching methods tend to widely emphasize on recall and rote learning rather than a journey towards enlightenment and reflective experience, which generate useful knowledge and skills; laboratories for science were widely underutilized or wrongly utilized, that is, they are used for traditional whole class teaching rather than practical work; lack of maintenance of equipments; lack of equipment and resources in general is a major constraint to effective teaching and learning process and there were also striking inequality among schools in terms of resources, resulting in lack of uniformity in science curriculum implementation.

Furthermore, the study indicated a significant sex-based difference in participation in science education. Thus, it has been observed that a far fewer number of female students attend science education than their male counterparts. This disparity in the participation of the two sexes in science education could be attributed mainly to cultural factors and stereotypes which make it difficult for female learners to attend science and related subjects. Even though this
difference can also be ascribed to cognitive styles and learning capacity of individual students, it appears to be negligible as compared to social and cultural factors. Thus, we can conclude from this study that girls’ participation in science education is low, inequitable, and inefficient. This implies that talented female workers were missing from science-related careers and that more girls could be attracted to science fields and careers if they were given encouragements and support.

Moreover, the results of this study indicated that there was a considerable level of unfavorable attitude among students toward science, negative academic self-concept of science, less strategic of students and this feeling was often accompanied by hatred of science and science teachers. There was a general feeling among the vast majority of students that science is a difficult subject. Not surprisingly, this unfavorable attitude towards science was more noticeable among female students. Too much theoretical teaching that renders the subjects abstract and boring and the resulting poor academic achievement of students have contributed highly to these feelings. Traditional socio-cultural attitudes, in which harder and more demanding tasks are regarded as masculine, present science as a male domain, reserved only for the specially gifted minority. Such attitudes transmit poor expectations and favor sex discriminations.

Science, especially, is also regarded by many as a tedious experimentation in laboratory, and not as a creative and cultural activity and a source of development. It was evident from the results of this study that boys have higher level of positive attitude towards science than girls and achieve better than girls. This means, in this study, one of the significant factors influencing students’ academic achievement in science was attitudes of students toward science. The results of this study showed that attitude was one of the significant variables related towards students’ academic achievement in science. What becomes clear from the result of study on the subject,
mainly as a result of a serious consideration and investigation of the problem that girls’ attitudes to science were significantly less positive than that of boys and their academic achievement too.

More importantly, data from this study showed conclusively that girls science education does not remediate this lack of experience and leads them to lack of experiences in science and leads to a lack of understanding of science and contributes to negative attitudes to science and to less achieve in science. This early established difference in the interests and activities of boys and girls result in parallel differences in their science performances. Sex differences in attitude towards science, in favor of boys, as indicated by the results of this study can be attributed to the socio-cultural roles of boys and girls in Ethiopian society. Boys in Ethiopian society spend most of their time at study because they have less home activities than girls and therefore have plenty of time to study and can complete the assignments given by teachers which could contribute to their relatively higher level of academic achievement in science.

The above discussions and findings of the study lead to the following specific implications of the study for the educational policy makers:

- There should be policy formulation that will ensure adequate provision of standards for instructional materials.
- All science subject teachers should be exposed to and trained on the art of provision of instructional materials on regular basis so as to make teaching-learning more effective.

There are also some important resource-related issues where policy is needed;

a) Class size standard is needed
b) Teachers’ work load standard is needed
c) Teachers’ qualification standard for particular grade level is needed
d) Strengthen efforts to close the academic achievement gap through high standards, accountability and more information should be given for parents at policy level.

All of these challenges identified may have their own causes and possible solutions. However, the researcher wants to comment only on the following issues.

1. Science teachers’ deployment is a critical issue. It represents by far the largest recurrent cost of teaching science. Yet, often teacher posting is not driven clearly by need. Woreda (district) and regional level planning data may not be able to identify the science teacher establishment in particular school and are even less likely to be able to relate this to the number of students actually studying science. Formula-based staffing that relates science teacher posting to indicators of numbers of science students must be used.

2. Although lack of material resources (equipment, laboratory environment) can be a very real challenge on how much science can be taught, there is evidence that this reason is posed even by those teachers, and workers in relatively well-resourced schools. Teachers’ poor motivation, lack of skills in planning flexible and creative lessons, and lack of understanding of curriculum objectives are all likely to be contributory factors in determining why so much of the science that is taught appears to diverge from the expectations of the curriculum developers. On occasions, it may also be these expectations which are at fault. Hence, teachers have to get training on how to use the existing materials and how to implement the revised curriculum.

3. Although what students actually experience in science education is largely determined by school-level decisions about who teaches them, under what conditions, and with what resources, not much is known about allocation practices within the school, or between types of schools. It is noted that often grossly disproportionate allocations are made for
the study of science. Class sizes are often excessively large, and taught in the poorest conditions by limited number of teachers. Hence, allocation at school level must be similar

REFERENCES

ABSTRACT

Systemic chemical education reform [SCER] has gained a great importance internationally due to the competitive job market and global market economy which create global challenges and stresses on our current educational system. SCER is a dynamic process that requires constant communication, evaluation and has implications for curriculum, instruction, assessment, and professional development. It occurs in all aspects and levels of education process those impacts in all stakeholders. The present work presents the systemic view of CER which means the change of our chemistry educational system from linearity to systemic in which we design the chemistry curricula and write the contents systematically. Also the content was taught by using SATL strategy on the light of systemic standards and objectives, which are measured by systemic assessment. In this paper we will shed light on systemic curriculum design [SCD], systemic content [SC], and systemic assessment [SA] in the frame of Systemic Chemical Education Reform. [AJCE 4(1), January 2014]
INTRODUCTION

On reaching the 21st century and with the development of communication media and the ease of information flow, the world seemed to be living in a small village full of developed and complicated information. The new century generation has challenges that are difficult and numerous, either to find its place in this universe or the international flood of science and knowledge will take him/her away. So it is a must to make a revolution in our educational systems so that to create a generation that is able to see the whole and not to miss some parts of it. To connect facts and concepts in a global context, we want as we live in 21st century to reach by our educational system from linearity to systemic. So we searched for an educational system growing the systemic way of thinking of our students that is one of the most important characteristics of Global Era.

Here is the systemic education reform which means the change of our educational system from linearity to systemic in which we design the curriculum and write content systemically, which presented by SATL strategy on the light of systemic standards, objectives and assesses by systemic assessment.
Systemic diagram in fig -1 shows the components of systemic education. By Systemic Education [SE] it means (i) education in the higher learning levels [Synthesis-Analysis-Evaluation-then Creativity], (ii) education leads to highly ordered cognitive structure, (iii) education concerned with meta-cognition rather than cognition, (iv) education concerned with systemic thinking which is one of the important learning outcomes of SATL and necessary for preparation of citizen live in the global Era.

It was stated previously that systemic education reform was based on changes in content, pedagogy and assessment. However, we present here a new looking for SER which means reform of all the above components of the SE. This means systemic reform of standards, objective, Systemic Curriculum Design [SCD], Systemic Content [SC], Systemic teaching strategy [SATL] (1-3) and Systemic Assessment [SA] (4-7).
In this paper we will shed light on SCD - SC- SA in the frame of Systemic Chemical Education Reform [SCER].

I- SYSTEMIC CURRICULUM DESIGN [SCD]

The first part of our study on systemic chemical education reform [SCER] is the systemic curriculum design. SCD can be illustrated in the following systemic diagram Fig.2.

![Systemic curriculum design](image)

Fig.2: Systemic curriculum design

The above diagram shows the interacted components of systemic curriculum. Curriculum should be designed on the light of the university mission and vision, standards and objectives which should be addressed on the light of local and global requirements. SCD will leads to program, and learning outcomes which fulfill total quality management (TQM), total quality control (TQC) and total quality assurance (TQA) of the educational systems (8).

National requirements were determined by the university, cultural, social, economic and competitive job market requirements which fulfill TQA. All these factors affect each other and affected by other components of SC. Global requirements were determined by global economy.
market requirement and competitive global job requirements beside the needs for preparation of global citizens.

Learning outcome is a clear statement of that which a learner is expected to be able to do or to know at the end of his/her program/course study in chemistry. It provides easier access to the chemistry curriculum by those wishing to accredit their knowledge and experience gained outside the university. Also help to ensure that appropriate assessment methods are adopted, and thereby increase the potential for diagnostic assessment. Program outcome is a statement of that which a student is expected to be able to do or know at the end of his/her chemistry program/course of study. Program outcome includes statements of personal transferable skills, or key skills in chemistry.

The following are the chemistry curriculum design procedures (8):

1. Instructional Strategies: Make chemistry courses effective, popular, and keep the course materials at the best reading level. How to design chemistry exercises?
2. Work Plans: Where to start? How to reduce chemistry course costs? How to reduce chemistry course length? How to estimate design time?
3. Learner Analysis: What you need to know about chemistry learners? Where to get this information?
4. Task Analysis: What are the chemistry sources of data? How to build the chemistry course at the learners' level? What is the best way of sequencing chemistry course content? How to link chemistry learning to job market requirements?
5. Principles of Learning: How much theory/background material to include in the chemistry course? What is the best approach(s) used to motivate learners in the chemistry courses? What types of indoor and outdoor activities to schedule based on time?
6. **Objectives and Tests**: What Types of objectives? How to write objectives quickly and easily on the light of standards? How to design performance checklists for chemistry Labs?

7. **Validation and Assessment**: What to include in a course assessment? What assessment forms you can use in chemistry? How to measure learning outcomes?

All the above mentioned questions should be clarified by curriculum designer team and constitute the guidelines for the curriculum designer. Chemistry Curriculum Design Procedure works systemically, i.e. each component strongly interrelated to the other components as illustrated in the systemic diagram Fig.3

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Fig.3: Systemic diagram of the Chemistry Curriculum Design Procedure
II-SYSTEMIC CONTENT [SC] OF THE CHEMISTRY COURSE MATERIALS

The second part of our study about SCER is the systemic content [SC] of course materials. In systemic chemistry education we arrange the course content materials in a systemic way (1). This means arrangement of concepts or issues through interacted systemic in which, all relationships between concepts and issues are clear as shown in Fig.4.

![Diagram of systemic arrangement](image)

Fig.4: Illustrates the idea of systemic arrangement of chemistry course materials.

However, linear presentation of chemistry course materials means arrangement of chemistry issues and concepts in a sequential presentation as in Fig.5.
In practice, the systemic building strategy allows the teacher to build up sequentially a single concept map starting with prerequisite concepts required for the student before he/she starts on a systemic approach to learning. Figure 6 shows this strategy for building the closed cluster of chemistry concept map (systemic; SD1-SD5) involving the five concepts entitled E, F, X, Y, Z (1).

**Figure 6.** The evolution of a completed closed chemistry concept cluster from a starting point
The instructor has in mind the linear concept structure shown in Figure 5, which he/she wants to develop into the closed cluster (systemic) shown as Figure 4. The prerequisites are simple bi-directional relationships between the concepts. Thus, initially, there are four unknown (to the student) relationships in the final cluster of concepts (Figure 6). The full closed cluster concept map [SD5] can be developed in four stages by sequentially introducing the (initially) four unknown concepts. At each step, another part of the final closed concept cluster is added and developed. This process clearly illustrates the systemic constructivist nature of systemic arrangement of the course content materials. This building strategy could be used in different branches of chemistry.

APPLICATION OF SYSTEMIC BUILDING STRATEGY IN CHEMISTRY

Systemic building strategy of course content materials was used to develop courses in Organic chemistry, Inorganic chemistry, physical chemistry, and analytical chemistry. Systemic chemistry courses were produced by the Science Education Center at Ain Shams University, and experimentation in different university and school settings.

Pre-College Courses

SATL-Classification of Elements

We present now the details of the transformation of the usual linear building strategy fig.5, usually used to build this subject that involves separate relationships, to the corresponding systemic building strategy fig.4, which involves closed concept cluster (systemic) that presents the systemic relationships (9).
Stage-1: Linear arrangements of periodicity of the properties of elements

The periodicity of the properties within the horizontal periods is linearly arranged and illustrated as in the diagram in Figure 7, and within the vertical groups is linearly arranged as illustrated in the diagram in Figure 8.

![Diagram](https://example.com/diagram.png)

Fig.7: Linear arrangement of periodicity of properties of the elements within the periods.
Fig. 8: Linear arrangement of periodicity of properties of the elements within the groups.

The previous diagrams of periods and groups represent linear arrangement of properties with separated chemical relations between the atomic number and Atomic radius – Ionization energy - electron affinity - electro negativity - metallic and non-metallic properties - basic and acidic properties.

Stage-2: Systemic arrangement of periodicity of the properties of elements

The periodicity of the properties through the periods can be arranged systemically by changing the linear arrangement in the linear diagram Figure (7) to systemic arrangement as illustrated in the systemic diagram (SD1-P) Figure (9).
Also the periodicity of the properties within groups can be illustrated systemically by changing linear arrangement in Figure 8 to systemic arrangement in systemic diagram (SD1-G) Figure 10.
Stage-3: Completion of the systemic arrangement of the periodicity of properties

After we start systemic arrangement of the periodicity of physical and chemical properties of the elements, we can introduce more relations to complete the systemic diagram by modifying systemic diagrams (SD1-P) Figure (9) to (SD2-P) Figure (11), for periods, and (SD1-G) Figure (10), to (SD2-G) Figure (12) for Groups.

Figure (11): Systemic Diagram (SD$_2$ - P) for the complete systemic arrangement of Periodicity of the properties of the elements within periods.
The above mentioned content was experimented in Egyptian secondary schools. Fifteen systemic content based lessons in inorganic chemistry taught by SATL method over a three-week period were presented to a total 130 students (9). The achievement of these students was then compared with 79 students taught the same material using standard (linear arrangement), and traditional teaching method.
The results of experimentation

Figure 13: Percent of students in the experimental groups who succeeded (achieved at a 50% or higher level). The bars indicate a 50% or greater achievement rate before and after the systemic intervention period.

Figure 14: Percent of students in the control groups who succeeded (achieved at a 50% or higher level). The bars indicate a 50% or greater achievement rate before and after the linear intervention period.
The results from the pre-university experiment point to the following conclusions:

- Teachers’ feedbacks indicated that the systemic content taught by systemic approach seemed to be beneficial when the students in the experimental group returned to learning using the conventional linear approach.

- Students used systemic content and taught systematically improved their scores significantly after being taught by using SATL techniques.

**University Courses**

We have three university courses prepared on the basis of systemic arrangement of content. SATL-Aliphatic chemistry, SATL-Aromatic Chemistry and SATL-Heterocyclic chemistry. A sample of this work will be discusses in this work.

**SATL-Heterocyclic chemistry: [e.g. SATL-Furan Chemistry]**

We use heterocyclic chemistry to illustrate, again, how a subject can be organized systemically, to help students to fit the new concepts to their own mental framework (10).

**Stage-1: Linear arrangement of Furan chemistry:** Figure 15 summarizes all the significant linear separate chemical reactions of furan, the model heterocyclic compound.

![Figure 15. The classic linear arrangement of Furan chemistry](image)
Stage-2: Systemic arrangement of the Furan chemistry:

The Furan chemistry can be arranged systemically by changing the linear arrangement in the linear diagram (Figure 15) to systemic arrangement as illustrated in the systemic diagram (SD1) as in Figure 16.

Figure 16: Systemic arrangement [SD1] of the furan chemistry

Stage-3: Completion of the systemic arrangement of Furan chemistry:

After we start systemic arrangement of Furan chemical properties, we can add more relations to complete the systemic diagram SD-1 to give SD-2 as in Fig.17.
Figure 17. Complete systemic arrangement [SD-2] of Furan chemistry

The above mentioned content was experimented as part of heterocyclic chemistry course taught by using the SATL technique to the 3rd year students at Ain Shams University. A portion of the one-semester course (10 lectures, 20 hours) was taught to students during the academic years 1999-2000 (10).

The data summarized in Table 1 below shows that student use of systemic content were significantly improved after being taught by using SATL techniques.

Table -1: Percent increase in student scores

<table>
<thead>
<tr>
<th></th>
<th>Before intervention</th>
<th>After intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear questions:</td>
<td>37.32 %</td>
<td>49.53 %</td>
</tr>
<tr>
<td>Systemic questions:</td>
<td>21.19%</td>
<td>90.29%</td>
</tr>
<tr>
<td>Total:</td>
<td>32.52%</td>
<td>69.1%</td>
</tr>
</tbody>
</table>

These results are statistically significant at the 0.01 level.
Systemic to Laboratory Instruction

Applying Systemic arrangement to laboratory instruction reveals the following advantages, which constitute the principles of benign analysis (11):

- Smaller amounts of Chemicals are used
- Recycling of Chemicals
- Experiments are done with fewer hazards and more safety
- Experiments are done more rapidly
- Students easily acquire a working sense of the principles of green chemistry

Classical laboratory-oriented subject of qualitative analysis involves the application of linearly obtained chemical information to an unknown solution in a linear way. In contrast to the linear approach of learning chemistry of cations from a laboratory experience, a systemic approach has been developed that focuses attention on individual species (Figure 18). Applying this approach to laboratory instruction allows students to experience the colors of chemical species, their solubility characteristics, and their redox behavior.

![Figure 18: Systemic Investigation of species A⁺ (SI-Plane)](image)

This diagram shows the systemic arrangement Investigation Plane [SI-Plane] for qualitative investigation of the species (A⁺), the preparation of (A⁺) compounds and the conversion of the species.
Example-[A]: Systemic Investigation of [Pb$^{++}$] (SI-1): Lead Cycle

The students follow the plane (SI-1) to investigate (Pb$^{2+}$) in a series of experiments (1-4) in a single test tube on a small sample of lead nitrate (0.5 ml), then they recycle the product of (Exp. 4) to Pb(NO3)2 (Cf. SI – Final).

Example - [B]: Systemic Investigation of [Ag$^+$] (SI-2): Silver Cycle

The students follow the plane (SI-2) to investigate (Ag$^+$) in a series of experiments (1-3), then recycle the product of (Exp.3) to AgNO$_3$ (Cf. SI-2-Final).
Results of Experimentation

The experimentation results showed that the benign scheme based on systemic arrangement of investigation experiments reduces the consumption of chemicals in comparison with the classical scheme as shown in table (2). This means low cost, and less pollution (11).

Table 2: Amount of salts needed for experimental group (Benign scheme) and reference group (Classic scheme).

<table>
<thead>
<tr>
<th>Salts</th>
<th>Amount required (gm / 50 Students)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classic Scheme Solid (g)</td>
</tr>
<tr>
<td>Pb(NO₃)₂</td>
<td>100</td>
</tr>
<tr>
<td>Al(NO₃)₃</td>
<td>200</td>
</tr>
<tr>
<td>CrCl₃·6H₂O</td>
<td>200</td>
</tr>
<tr>
<td>NiCl₂·6H₂O</td>
<td>200</td>
</tr>
<tr>
<td>Co(NO₃)₂·6H₂O</td>
<td>200</td>
</tr>
<tr>
<td>CdCl₂·5H₂O</td>
<td>150</td>
</tr>
<tr>
<td>BaCl₂·2H₂O</td>
<td>200</td>
</tr>
<tr>
<td>MgSO₄·7H₂O</td>
<td>200</td>
</tr>
</tbody>
</table>

The results, of experimentation indicate that a greater fraction of students use the systemic content and exposed to systemic techniques in the experimental group, achieved at a
higher learning level than did the control group taught by the linear content and classical approach.

III-SYSTEMIC ASSESSMENT [SA]

The third part of our study about systemic chemistry education reform [SCER] is the systemic assessment [SA] to assess student achievement in chemistry. By SA we actually measure the change in cognitive structure of student after each learning process.

We have proposed systemic assessment (SA) of learners, aiming to a more efficient evaluation of the systemic-oriented objectives in the SATL model and effective tool for assessing students' meaningful understanding of systemic chemistry topics in secondary and tertiary levels (4-7). Systemic assessment is the key component in the systemic curriculum. It is used during the systemic course to monitor the student progress (formative) and at the end of the course to monitor the progress of students’ cognitive structures (summative).

Students answering systemic assessment questions (SAQs) are able to (i) connect several concepts at once, applying them in a new situation, and synthesize them to create a comprehensive meaningful conceptual structure, (ii) select specific concepts that fit the particular item and combine them into integrated meaning in their systemic cognitive structure, (iii) illustrate systemic meaningful understanding of scientific concepts.

**Why Systemic Assessment (SA) in chemistry?**

Systemic assessment (SA) has the following advantages:

1. It measures the cognitive structure from the cumulative (quantitative) to the interactive and tuned (qualitative)
2. Assess students higher-order thinking skills in which students are required to analyze, synthesize, and evaluate
3. Measures the students’ ability to correlate between chemistry concepts
4. Enables the students to discover new relation between chemistry concepts
5. Gives the students rapid feedback during the term about how well they understand the chemistry course material
6. Assess the students in a wide range of chemistry concepts in the course unites
7. Measures the systemic ILOs, beside separate Linear ILOs
8. Develop the ability to think systemically, critically and creatively, and solve problems
9. Very easily scored
10. Being objective, realistic and valid.

Types Systemic Assessment Questions [SAQs]

SAQs are the building questions of any systemic objective test [SOT] namely Systemic Multiple Choice Questions [SMCQs], Systemic True, False Questions [STFQs], Systemic Matching Questions [SMQs], Systemic Sequencing Questions [SSQs], Systemic Synthesis Questions [SSynQs]. Different examples from different branches of chemistry were previously published (4-7).

Systemic assessment questions forms are valid and reliable tools for assessing students’ achievements, treated by systemic content [SC], and SATL at higher learning levels.

REFERENCES


SYSTEMIC OBJECTIVE TEST IN MEDICAL BIOCHEMISTRY
PART 1- METABOLISM OF CARBOHYDRATES

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ABSTRACT
A very important element of the teaching plan is students’ assessment. Assessment should be very objective and backed up with feedback. A necessary condition for this type of evaluation is the formation of questions. The questions should lead the thinking process of the students with skills and clarity of thought. In this way, these questions will serve as clear ideas and help to develop the imagination and the research. Such innovation provides systematic evaluation, which is based on systematic diagram. Testing plays an important role in this system. The objective test is created in a way that a different estimator that assesses independently will achieve the same results for the introduced level of knowledge and abilities based on true answers. In comparison with the traditional objective test, the systemic objective test includes many demands that are completely structured; it covers a huge part of the educational schedule, and measures high levels of education (synthesis, analysis and estimation). In this article, we will introduce STFQs, SMCQs, SSQs, SSQs, ASQs, and SCQs as examples of the systemic objective test in medical biochemistry. [AJCE, 4(1), January 2013]
INTRODUCTION

Asking questions lies on the basic foundation of communication, especially the lecturer-student communication. It a process that lecturers and students come across every day. Asking questions is a practice that does not only serve to know who knows the answer is, it also supports the student to make him/her more competent to find the right answer through different ways (1). In most cases, asking questions helps the lecturer to check students’ knowledge and verify if they did their work.

According to Blum’s taxonomy, the abilities of thinking are classified in six levels, in a hierarchic way from the lowest level to the highest one. Blum’s taxonomy was revised adapting the questions according to the levels of thinking. It is very important to understand that every type of question introduces a way of thinking, listed in a hierarchic way as well. Nowadays, questioning is not as it used to be in the traditional teaching, where only the teacher used to ask; now it’s a mutual process between the teacher and the student. Systemic objective test can challenge students and test higher learning levels (analysis, synthesis, and evaluation (2).

Analytic questions are questions of the high level, they require critical thinking. Analytic questions usually require two different kinds of thinking; to separate the knowledge in components and to see the connections between two or more components. The synthesis questions constitute another kind of questions of the high level. These questions expect from the student to put in order the ideas that they learned previously and combine these ideas in a way to create new models or new products. The evaluation questions stand on top of the taxonomy. These questions expect the student to do two important things. The first thing that they have to do is to create criteria to support their judgment and the second is that they have to judge by using these criteria.
METHODOLOGY

The study was carried out at the University of Shkoder “Luigj Gurakuqi” (Albania) in the Faculty of Natural Sciences, at the Department of Biochemistry, with the students of the first study degree, in the subject of biochemistry. Initially, the students were shown the application of the SATL as the module “Part 1- Metabolism of Carbohydrates” was being taught. Students were divided into groups at will. The first group acts as an experimental group whereas the second operates as controller. The research involved 65 students in the control group, which was taught using the linear approach; 115 students formed the experimental group, which was taught using SATL methods illustrated in the systemic diagrams. The lecturer provides both groups with the necessary explanations. The module was taught for a semester. Two exams were organized, one before method application, the other after its application for equivalence.

The examination for both groups used to measure the achievement over the subject matter incorporated in both the system and the linear type questions. The final data in terms of students’ achievement are shown Figures 1 and 2. The exams incorporated systematic and linear questions for both groups. The best assessment is 100 points; the minimum passing assessment is 35 points.

The success of the systemic approach to teaching biochemistry was established by using an experimental group, which was systemically, and control group, which was taught in the classical linear manner. Following the teaching exercise through SATL technique, it is quite natural to assess the students through the same medium. This not only helps to determine the scale of comprehension the learner acquires via SATL lesson, but also examines such aspects of students’ knowledge that they learn through classical teaching methods.
Systemic learning based test, presently known as systemic objective test (SOT), could be an instrument for determining the scale of learning level as: analysis, synthesis and evaluation. Systemic objective tests are developed and the following few examples explain this aspect of a SATL teaching lesson.

To make up systemic questions, the geometric forms of the questions should be determined. Shapes are the building units of the systemic questions (3-4)). Geometric shapes are different such as triangular, quadrilateral, pentagonal, hexagonal, etc, depending on the number of concepts that are incorporated in the diagram. Construction of systemic questions requires the realization of some requirements such as:

- Determination of the types of relations between the given concepts.
- Determination of the size of the building of systemic diagrams.
- The items in the left (column A) are usually called premises. The items in the right (column B) are called responses.
- Provide the information in the stem and keep the options as clear systemics.
- Put in the stem the information and make the problem clear and specific.

The following examples are intended to illustrate how systemic question have been used in biological chemistry (5).

**Type I:** Systemic True / False Questions (STFQs).

Systemic True/False Questions are well suited for testing students’ comprehension, synthesis, and analysis. STFQs require a student to assess whether a statement is true or not, however, they require a student to assess whether a systemic diagram is true or false.
Example

Q-1. The systemic diagram represents the correct relations between major pathways. Indicate which of the following systemic diagrams are true (T) and which are false (F):

a. (----- )

b. (----- )

c. (----- )
**Type II: Systemic Matching Questions (SMCQs).**

Systemic Matching Questions measure the student's ability to find the relationship between a set of similar items each of which has two components, their relationships, and arrange them in a given systemic diagram. The student has to choose from the concepts and given relations and create a systemic diagram.

**Example**

**Q-1.** Choose compounds from column (A) and metabolic processes from column (C) to build the correct systemic relations in column (B):

<table>
<thead>
<tr>
<th>Column (A)</th>
<th>Column (B)</th>
<th>Column (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycogen</td>
<td>Glycogen</td>
<td>glycogenesis</td>
</tr>
<tr>
<td>Pyruvate</td>
<td>oxidative</td>
<td>oxidative</td>
</tr>
<tr>
<td>Glucose</td>
<td>decarboxylation</td>
<td>decarboxylation</td>
</tr>
<tr>
<td>Fatty acid</td>
<td>lipogenesis</td>
<td>lipogenesis</td>
</tr>
<tr>
<td>Acetil - CoA</td>
<td>glycolysis</td>
<td>glycolysis</td>
</tr>
<tr>
<td>Triacylglycerol</td>
<td>gluconeogenesis</td>
<td>gluconeogenesis</td>
</tr>
<tr>
<td></td>
<td>acyltransferase</td>
<td>acyltransferase</td>
</tr>
<tr>
<td></td>
<td>phosphatase</td>
<td>phosphatase</td>
</tr>
<tr>
<td></td>
<td>glycerol</td>
<td>glycerol</td>
</tr>
<tr>
<td></td>
<td>FFA</td>
<td>FFA</td>
</tr>
<tr>
<td></td>
<td>CoASH</td>
<td>CoASH</td>
</tr>
</tbody>
</table>

*Answer:*
Type III. Systemic Sequence (SSQs) measure students’ skills to determine the concept and the relationships according to the given sequence in the systemic diagram.

Q-1. Put the following compound in the correct sequence in the following systemic diagram that shows metabolism of fructose.

Answer:
Type IV. Synthesize Systemic Questions (SSQs) measure various kinds of knowledge, including students’ ability to correlate between concepts, formula, or events. The student determines the relation between the concepts in the systemic diagram.

Q-1. Build a correct systemic diagram to show the relations between major pathways: glycogenolysis, pentose phosphate, glycolysis, citric acid cycle, gluconeogenesis, glycogenesis.

Answer:

Type V. Analyze Systemic Questions (ASQs) assess higher-order thinking skills in which students are able to analyze. The student analyzes the concepts and their relations in the given diagram.

Q-1. Analyze the catabolic other fate of the glucose.
Type VI. Complete Systemic Questions (CSQs) assess higher-order thinking skills in which students are able to analyze. The student fills out the concepts or formulas, numbers or events that are missing in the given diagram.

Q-1. Complete the following systemic diagram to show glucose metabolism.
Answer

Graphs have been drawn to display the percentage of the students’ average scores on examination components indicated (linear questions or systemic question). On the left hand bar of each couple of graphs, the points before the exam have been displayed, whereas on the right hand bar the points of the exam after the application of the methods have been displayed.

![Graph showing average scores of the control group before and after the application of the SATL](image)

*Figure 1. Average scores of the control group before and after the application of the SATL.*

Figure 1 above shows the average scores of the control group before and after the application of the SATL. The control group had an average score of 28.12% on linear question and an average score of 24.04% on systemic questions before application while had an average
score of 30.24% on linear question and an average score of 26.82% on systemic questions after application.

![Figure 2. Average scores of the experimental group before and after the application of the SATL.](image)

Figure 2 shows the average scores of the experimental group before and after the application of the SATL. The experimental group had an average score of 24.20% on linear question and an average score of 19.25% on systemic questions before application while had an average score of 68.45% on linear question and an average score of 72.01% on systemic questions after application.

These data indicate a marked difference between the control group and experimental group. As can be noticed from the graphs, students of the control group encounter difficulties in the exam with regard to the systematic questions thus the control group had an average score of 19.25% contrasted to 24.04%. The experimental group achieved at a higher level as measured by the total average score on the examination (78.10 versus 28.54%).
Figure 3. Correlation of the points accumulated by the experimental group

Figure 3 above displays the correlation of the points accumulated by the experimental group before and after the application of the SALT. As can be noticed, there is a very good correlation. The correlation coefficient is 0.92.

CONCLUSIONS

Making up systemic questions in medical chemistry positions the students differently in the auditorium. The benefits of this new positioning are:

- Students develop their skills and abilities to recognize problems and to participate in their solution.
- Students use their critical thinking, problem solving and decision making abilities.
- Students demonstrate self-management skills.
- Students have a deep critical thinking for the problems that occur.
- Students organize their thinking in the process of systematic diagram completion.
• Students complete difficult systematic diagrams through systemic thinking. They improve their perception by increasing their observation skills.

• Students learn through creation and not through reproduction, therefore, they could increase their creativity.

REFERENCES
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:

\[
\begin{align*}
&\text{Gold for the sun and silver for the moon,} \\
&\text{Iron for Mars and quicksilver in tune} \\
&\text{With mercury, lead which prefigures Saturn} \\
&\text{And tin for Jupiter. Copper takes the pattern} \\
&\text{Of Venus if you please! ...}
\end{align*}
\]

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 Cu2 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 SO42-, tetraoxophosphate (V) ion as \( \text{PO}_4^{3-} \), \( \text{PO}_4^{2-} \), P4, Nitride ion as \( \text{N}_3^- \), \( \text{NO}_5^- \); trioxocarbonate (IV) ion as \( \text{CO}_3^{2-} \) 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 summary along with respective percentage

<table>
<thead>
<tr>
<th>Q.No</th>
<th>Alternatives</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>1</td>
<td>1(4%)</td>
<td>0</td>
<td>22(88%)*</td>
<td>2(8%)</td>
</tr>
<tr>
<td>2</td>
<td>5(20%)</td>
<td>6(24%)</td>
<td>4(16%)*</td>
<td>10(40%)</td>
</tr>
<tr>
<td>3</td>
<td>7(20%)*</td>
<td>7(28%)</td>
<td>7(28%)</td>
<td>4(16%)</td>
</tr>
<tr>
<td>4</td>
<td>2(8%)</td>
<td>20(80%)*</td>
<td>1(4%)</td>
<td>2(8%)</td>
</tr>
<tr>
<td>5</td>
<td>5(20%)</td>
<td>6(24%)</td>
<td>12(48%)*</td>
<td>2(8%)</td>
</tr>
</tbody>
</table>

* represents the correct alternatives to each question.

The numbers and percentage under each alternative letter 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

<table>
<thead>
<tr>
<th>S.No</th>
<th>Elements name</th>
<th>Correct answer</th>
<th>Incorrect answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boron</td>
<td>17(68%)</td>
<td>8(32%)</td>
</tr>
<tr>
<td>2</td>
<td>Barium</td>
<td>8(32%)</td>
<td>17(68%)</td>
</tr>
<tr>
<td>3</td>
<td>Sodium</td>
<td>22(88%)</td>
<td>3(12%)</td>
</tr>
<tr>
<td>Average</td>
<td>15.67(62.67%)</td>
<td>9.33(37.33%)</td>
<td></td>
</tr>
</tbody>
</table>

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$_3$N$_2$. 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$_2$O$_3$) were able to name the given covalent compound correctly, see Table 3 below. 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

<table>
<thead>
<tr>
<th>Compound</th>
<th>SO$_3$</th>
<th>N$_2$O$_3$</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Answer</td>
<td>5(20%)</td>
<td>5(20%)</td>
<td>5(20%)</td>
</tr>
<tr>
<td>Incorrect Answer</td>
<td>20(80%)</td>
<td>20(80%)</td>
<td>20(80%)</td>
</tr>
</tbody>
</table>

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 ($\text{NO}_3^-$). For instance, 80% of them gave a response as $\text{H}_3\text{N}$, 8% as H$_3$N, 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

<table>
<thead>
<tr>
<th>Scored points out of 10%</th>
<th>Frequency (f)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total (n)</td>
<td>25</td>
<td>100%</td>
</tr>
</tbody>
</table>

Graphically, students` achievement is illustrated as follow using the frequency distribution of achievement scored in Table 4 above:
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 polyatomic 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 planned as indicated in the table below (all dates are in the Ethiopian calendar):

Table 5: Action plan

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

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

<table>
<thead>
<tr>
<th>Q14</th>
<th>Symbols of elements</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Ba</td>
</tr>
<tr>
<td>Correctly named</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>Incorrectly named</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

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 polyatomic 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

<table>
<thead>
<tr>
<th></th>
<th>SO$_2$</th>
<th>N$_2$O</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correctly Answered</td>
<td>18</td>
<td>17</td>
<td>17.5(70%)</td>
</tr>
<tr>
<td>Incorrectly Answered</td>
<td>7</td>
<td>8</td>
<td>7.5(30%)</td>
</tr>
</tbody>
</table>

As one can deduce from the table above, on average, 70% of the students (72% SO$_2$ and 68% N$_2$O) 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.

<table>
<thead>
<tr>
<th>Q.No</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8(32%)*</td>
<td>0</td>
<td>17(68%)</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3(12%)</td>
<td>1(4%)</td>
<td>8(32%)</td>
<td>13(52%)*</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>14(56%)</td>
<td>9(36%)*</td>
<td>2(8%)</td>
</tr>
<tr>
<td>4</td>
<td>15(60%)*</td>
<td>3(12%)</td>
<td>3(12%)</td>
<td>4(16%)</td>
</tr>
<tr>
<td>5</td>
<td>1(4%)</td>
<td>16(64%)*</td>
<td>1(4%)</td>
<td>7(28%)</td>
</tr>
</tbody>
</table>

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 which 16% 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

<table>
<thead>
<tr>
<th>Scored Points out of 10%</th>
<th>Frequency(f)</th>
<th>Percent %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

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 to 4 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\(_2\)I\(_3\) and Sr\(_0\)I\(_2\). 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

<table>
<thead>
<tr>
<th>Scores (10%)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P1</td>
<td>0</td>
<td>4</td>
<td>16</td>
<td>16</td>
<td>28</td>
<td>24</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>P2</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>20</td>
<td>24</td>
<td>16</td>
<td>12</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>
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](image)

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

<table>
<thead>
<tr>
<th></th>
<th>Average percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-</td>
<td>49.2%</td>
</tr>
<tr>
<td>Post-</td>
<td>63.6%</td>
</tr>
</tbody>
</table>

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 Sareae Baadiyaa Rabe for GIIA_

_Student C: Health fi Nersii Argannee Karaa Xeenan Ramadamge GVIII A_

**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.
REFERENCES

1. Modic A.L., (2011), Student Misconceptions – Identifying and reformulating what they bring to the Chemistry Table, Montana State University, Research paper for Masters Degree Fulfillment.
5. Yalew E. (2004E.C), Basic Principles of Research and their implementations, Bahir Dar University, 4th Ed.

Appendix I
Observation check list

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

Appendix II

Pre implementation of action

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) $\text{SO}_3$ : __________________________
   b) $\text{N}_2\text{O}_3$ : __________________________

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

<table>
<thead>
<tr>
<th>NO</th>
<th>Element Name</th>
<th>Symbol of the element</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Boron</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>Barium</td>
<td>Ba</td>
</tr>
<tr>
<td>3</td>
<td>Sodium</td>
<td>Na</td>
</tr>
</tbody>
</table>

Appendix III

Post implementation of action

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

8. Which one of the following could be the symbolic representation of oxygen?
   A. O       B. $\text{O}_3$       C. $\text{O}_2$       D. $\text{O}^{2-}$

9. Which one of the following alternatives indicates the ratio of strontium to iodine in the formula of Strontium iodide ($\text{SrI}_2$)?
   A. 1:3       B. 2:3       C. 0:2       D. 1:2

10. Barium hydroxide is an alkali earth metal base. Which one of the following could represent the chemical formula of barium hydroxide?
    A. BOH       B. BaOH       C. $\text{Ba(OH)}_2$       D. BaOH$_2$

11. Choose the alternatives that contain hydrobromic acid formula.
    A. HBr       B. $\text{H}_3\text{B}$       C. $\text{BH}_4$       D. A and B are correct

12. Which one of the following stands for the chemical name of $\text{HNO}_3$?
    A. Pernitrate acid
    B. Nitric acid
    C. Nitrous 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.

<table>
<thead>
<tr>
<th>NO</th>
<th>Symbol of the element</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ba</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Na</td>
<td></td>
</tr>
</tbody>
</table>

**ACKNOWLEDGEMENT**

Primarily, I would like to thank all N12 section students who devoted a lot of their time with me while conducting this action research. Secondly, my great thanks go to KCTE administrative bodies for supplying me with internet service that facilitated my work and provided me with different online resources. At last, I would like to extend my thanks to all department colleagues.
THIS ACRICE SUCCESSFULLY STARTED WHAT SHOULD BE A REGULAR SERIES

John Bradley (South Africa)
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The 1st African Conference on Research in Chemistry Education opened in the Africa Hall, UNECA, and Addis Ababa, where seven years previously the Federation of African Societies of Chemistry had been inaugurated. The formal opening was led by Prof Temechegn Engida (Immediate Past President of FASC and Conference President) and supported by Dr Aljandra Palermo (RSC/PACN), Prof Jan Apotheker (IUPAC-CCE) and Prof Motaza Khater Immediate Past Vice president of FASC.

The program comprised 8 plenary lectures, 16 keynote lectures and 5 oral presentations. There were about 150 participants from Ethiopia, Egypt, South Africa, Nigeria, USA, Japan, Turkey, Netherlands, Greece, Norway, Poland and Russia. The large and pretentious Africa Hall somewhat overpowered the modest number of participants, who nevertheless patently enjoyed the 3-day exposure to an eclectic mix of presentations. Whilst most presentations had some explicit research reporting, others had either a research overview or awareness-creating objective.

Illustrative of the last of these objectives were presentations by Leiv Sydnes and by Wafaa Abdou on Ethics and Safety and Security, both of course with chemistry and chemicals focus. These raised awareness of important challenges for chemistry educators and researchers in chemistry education: how to include the development of understanding of “chemical responsibility” into chemistry curricula.

The educational possibilities of ICT were the subject of several presentations. The plenary lecture by Temechegn Engida provided a stimulating overview and advocacy for
amending the familiar acronym PCK to TPCK. Boshra Awad reviewed the scope and limitations of various electronic devices based upon her survey of Egyptian practices. Plenary and keynote lectures by American researchers (Gregory Shelton, Diana Mason) served to remind participants that poor quality content and design remains of little value even when presented through new technology. ICT may have particular value when the tools are appropriate, as exemplified by Marietjie Lutz’s report of the use of cell phones instead of clickers in large classes. In cell phone use Africa stands in the front rank, as compared to use of iPads and related devices.

The gap between national school curricula in chemistry and the educational needs and capacity of the country emerged in a number of contributions. John Bradley introduced the gap in the context of the conference theme – Chemistry Education for Human Development in Africa. Gebrekidan Tesfamariam provided detailed research experience from attempts to establish hands-on practical work in schools in the Mekele district of Northern Ethiopia. He showed that whilst the Ethiopian national curriculum asserts “practical work is included as a key element”, no practical work of any kind happened in these schools. When, after suitable preparation, micro scale practical activities were introduced, the response was very positive from both teachers and learners.

Zafra Lerman warned of the need to avoid development of a two-class society: the scientifically literate and illiterate. In the light of this warning, African Ministries of Education need to have the courage to think through their school curricula and their implementation, focusing on local realities, but without ignoring global trends. Examples of curriculum development elsewhere can stimulate local thinking. The prime importance of motivating learners (as recognised in the Netherlands and described by Jan Apotheker) can surely be one such stimulus for local thinking. The systemic approach to teaching and learning, described in
the opening plenary lecture of Ameen Fahmy (Conference Vice President), is surely also another. The many examples reported by Fahmy of improved learning in a variety of contexts in Egypt, should be food for thought for all Ministries of Education on the continent.

Also encouraging the re-thinking of curricula was the series of quick demonstrations by Michael Katz; interesting and unexpected phenomena provide motivation and cry out for explanation.

In conclusion, this ACRICE successfully started what should be a regular series. There were pre-conference workshops on ICT, the Systemic Assessment in Chemistry, Safety and Security and Micro scale chemistry. The basic concept here of providing closer engagement with topics of potential value, especially for local educators, is welcome. Opinions differed as to whether these should have been embedded within the conference. But this, like many other aspects of ACRICE-1, is less important than that a process has begun: ACRICE-1 was the first! ACRICE-2 should be held in two years time, perhaps in Egypt or South Africa.
THE CONFERENCE MARKS AN IMPORTANT STEP FOR CHEMISTRY EDUCATION IN AFRICA

Jan Apotheker (The Netherlands)
Email: J.h.apotheker@rug.nl

On the occasion of the celebration of the 50th anniversary of the African Union, the Federation of African Societies of Chemistry (FASC) and the Addis Ababa University (AAU) organized the first African Conference on Research in Chemistry Education (ACRICE-1). The conference was held in the same venue where 7 years ago the FASC was founded, that is, the Africa Hall found in UNECA premises in Addis Ababa and where the former Organization for African Unity (OAU) was established.

Around 150 participants attended the conference, with invited speakers from USA, Russia, Japan, South Africa, Egypt, Ethiopia, Nigeria, Norway, the Netherlands, Greece, Turkey and Poland.

The conference marks an important step for chemistry education in Africa. Chemistry education is an important factor in meeting the challenges humankind faces in the coming years. In order to improve education conferences where people can exchange their experiences and research (on education) are vital for the growth and improvement of chemistry education. The organizers, Professor Temechegn Engida (Conference President) from Ethiopia and Professor Farouk Fahmy (Conference Vice President) from Egypt are to be commended for taking this initiative.

From IUPAC, Leiv Sydnes, Chair of CHEMRAWN, and Jan Apotheker, Secretary of CCE, were present. At the opening session Jan Apotheker was able to congratulate the organizers on behalf of IUPAC.
The conference ran from Thursday December 5th until Saturday December 7th. The use of ICT was one of the main themes in the conference with interesting contributions from sources as far apart as the USA, South Africa and Japan. Subjects ranged from the use of cell phones, apps for smart phones to special presentation software. Visualization was also an interesting topic where specific software was used to demonstrate chemical reactions.

As was the main idea of course there were also contributions from local chemistry education researchers. They gave us some interesting insights in developments and challenges in chemistry education both at the university level as well as the high school level. You do not always realize that the access to literature, instruments like Sci-finder, but more importantly chemicals, is not a matter of course as it is in most (western) developed countries.

Despite some organizational hurdles the conference was a success. During the conference dinner the organizers introduced participants to the Ethiopian culture and they were not only able to sample the Ethiopian cuisine, but were also introduced to Ethiopian music and dance.

For the continuing development of chemistry education and the research in chemistry education it is very important that this conference will be continued every two years in the future. At the closing of the conference Johannesburg and Egypt were indicated as possible venues for the second ACRICE-2.
The African Journal of Chemical Education (AJCE) is a biannual online journal of the Federation of African Societies of Chemistry (FASC). The primary focus of the content of AJCE is chemistry education in Africa. It, however, addresses chemistry education issues from any part of the world that have relevance for Africa. The type of contents may include, but not limited to, the following:

**RESEARCH PAPERS** reporting the results of original research. It is a peer-reviewed submission that deals with chemistry education at any level (primary, secondary, undergraduate, and postgraduate) and can address a specific content area, describe a new pedagogy or teaching method, or provide results from an innovation or from a formal research project.

**SHORT NOTES** containing the results of a limited investigation or a shorter submission, generally containing updates or extensions of a topic that has already been published.

**REVIEWS** presenting a thorough documentation of subjects of current interest in chemical education.

**LABORATORY EXPERIMENTS AND DEMONSTRATIONS** describing a novel experiment/demonstration, including instructions for students and the instructor and information about safety and hazards.

**SCIENTIFIC THEORIES** describing the scientific, historical and philosophical foundations of theories and their implications to chemical education.

**ACTIVITIES** describing a hands-on activity that can be done in the classroom or laboratory and/or as a take home project.

**INDIGENOUS KNOWLEDGE AND CHEMISTRY IN AFRICA** as a special feature that addresses the relationship between indigenous knowledge and chemistry in Africa. It could be in the form of an article, a note, an activity, commentary, etc.

**LETTER TO THE EDITOR:** A reader response to an editorial, research report or article that had been published previously. The short piece should contribute to or elicit discussion on the subject without overstepping professional courtesy.

All manuscripts must be written in English and be preferably organized under the following headings: a) **TITLE,** Author(s), Address(es), and **ABSTRACT** in the first page, b) **INTRODUCTION** reviewing literature related to the theme of the manuscript, stating the problem and purpose of the study, c) **METHODOLOGY/EXPERIMENTAL** including the design and procedures of the study, instruments used and issues related to the reliability and/or validity of the instruments, when applicable, d) **RESULTS AND DISCUSSION,** e) **REFERENCES** in which reference numbers appear in the text sequentially in brackets, each reference be given a separate reference number, et al and other notations like Ibid are avoided, and finally f) **ACKNOWLEDGEMENTS.**

When submitting a manuscript, please indicate where your manuscript best fits from the above list of categories of content type. All enquiries and manuscripts should be addressed to the Editor-in-Chief: email eic@faschem.org, PO Box 2305, Addis Ababa, Ethiopia.