AFRICAN JOURNAL OF CHEMICAL EDUCATION
AJCE

Vol. 2, Number 3, July 2012

A Publication of

Federation of African Societies of Chemistry

FASC

Chemistry for Sustainable Development in Africa

ISSN 2227-5835

www.faschem.org

AFRICAN JOURNAL OF CHEMICAL EDUCATION

AJCE

Enquiries and manuscripts should be addressed to the Editor-in-Chief: email eic@faschem.org, PO Box 2305, Addis Ababa, Ethiopia.

CONTENTS

EDITORIAL

EDUCATION AND OUTREACH ABOUT THE CHEMICAL WEAPONS CONVENTION (CWC): FOOD FOR THOUGHT FOR CHEMISTRY EDUCATORS IN AFRICA

Temechegn Engida
UNESCO-IICBA
Email: temechegn@gmail.com

BACKGROUND

As per the official definition (Organization for the Prohibition of Chemical Weapons – OPCW-1, Article II, p.3), "Chemical Weapons" means the following, together or separately:

(a). Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;

(b). Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;

(c). Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b).

Whereas a toxic chemical is conceptualized as any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals, its precursor is defined as any chemical reactant which takes part at any stage in the production by whatever method of a toxic chemical (1).

IUPAC undertook in 2002 an evaluation of the scientific and technological advances in chemical sciences that might have an impact on the implementation the CWC (2). Prior to the commencement of IUPAC's evaluation, the Director-General of OPCW stressed the importance of this evaluation as an assessment of the scientific foundations of the Convention in preparation for the First Review Conference of the CWC held later on 28 April 2003.

As stated by Pearson and Mahaffy (2) the evaluation report included a section on 'Education and Outreach' which recommended, among other things, that:

- *Greater efforts on education and outreach to the worldwide scientific and technical community are needed in order to increase awareness of the CWC and its benefits. An informed scientific community within each country can be helpful in providing advice to States Parties and in disseminating unbiased information to the public.*
- *Education of and outreach to Signatory States and non-signatory States could be helpful in increasing awareness of the importance of universal adherence to the Convention thereby enhancing safety and security for all States.*

In 2004, IUPAC and OPCW agreed on a proposal for a joint project on chemistry education, outreach, and the professional conduct of chemists that led to a joint IUPAC/OPCW international workshop held in Oxford/UK on 9–12 July 2005.

The Director-General of OPCW then established the Temporary Working Group on Education and Outreach in Science and Technology (TWG-EOST) in November 2011 in the framework of the Scientific Advisory Board (SAB) of OPCW. The Director-General stated, in his letter of invitation to the Members of the TWG-EOST, that the Group was established based on previous work in this area by individual SAB members in collaboration with other organizations such as the IUPAC and that the Group members are expected to make substantive contributions based on their areas of expertise.

Such sustained/continued efforts by the OPCW in promoting education and outreach among the scientific communities and the public at large in relation to the CWC and its implementation are to be applauded and hence my motivation for writing this essay as ‘food for thought’ for chemistry educators in Africa, mainly because I have the professional responsibility to do so both as the President of the Federation of African Societies of Chemistry (FASC) and as the Editor-in-Chief of the African Journal of Chemical Education (AJCE). It is ‘food for thought’ because the paper is not attempting to provide strategies for what should be done in the area but rather is trying to initiate thoughtful reflections towards what and how should be done by taking into account the contexts in African countries.

WHY EDUCATION AND OUTREACH ABOUT THE CWC?

There is a paradox in scientific and technological developments. It is obvious that advances in chemistry, the life sciences, and technologies will undoubtedly create considerable benefits for humankind—advances which could lead to improved health, a better environment, and more sustainable development. At the same time, new scientific discovery may lead to new risks, including the potential of new chemical compounds as chemical weapons (3).

As stated in a project proposal submitted to IUPAC (4) chemists played a formative role in the development of chemical warfare and the CWC aims to prevent any recurrence of this activity. But very few chemists know much about the CWC and what it covers, and few chemistry students realize that beneficial substances can be misused to produce chemical weapons.

According to OPCW (unpublished material) education and outreach in science and technology relevant to the CWC is important to the Convention's future implementation. Education and outreach serves a number of purposes including, *inter alia*:

- raising awareness of the Convention among the broad community of relevant professionals who should be aware of the Convention, including: students, educators, the global scientific community and the chemical industry;
- stressing the potential risks posed by the multiple uses of chemicals;
- contributing to national implementation of the Convention;
- contributing to the prevention of the misuse of toxic chemicals;
- facilitating chemical safety and chemical security; and
- building skills and capabilities in areas relating to the peaceful uses of chemistry.

It is therefore realistic to expect chemists and chemistry educators to understand the CWC, and develop and implement appropriate strategies it in their own contexts.

ISSUES TO CONSIDER

If chemists and chemistry educators agree that education and outreach in relation to the CWC is a necessary part of their professional obligations (as rationalized above), then they need to devise strategies that accomplish these obligations. Based on previous works by IUPAC and OPCW it seems that there is a general agreement that preparation and use of educational materials specifically devoted to the CWC and their implementation will be an unavoidable strategy.

On the other hand, it is clear that the existing educational materials for school science and university chemistry students are written mostly for a specialist audience, or have dealt only marginally with the topics central to chemical weapons or the CWC in general. It is also clear that revising or updating the existing chemistry education materials to address and deal with the CWC may not be realistic in the near future, particularly in African countries, mainly because of the financial, institutional and human requirements. It should also be noted that most educational materials for teaching-learning purposes are not cost-free whereas education and outreach related to the CWC could most probably be more accessible if those materials dealing with the CWC are available at no-cost. On the other hand, even if the educational materials be cost-free for the intended users, it is unlikely that their development will also be cost-free. So the question is as to who bears these costs. Could professional societies like national chemical societies, continental federations, and international unions be in a position to take the burden? Is there any hope that States Parties in Africa can be the major players in this regard? What are the most feasible strategies to convince education policy makers and curriculum developers to integrate issues related to CWC in already ‘crowded’ curricula in African education systems?

For effective and efficient implementation of the CWC it is necessary that the education and outreach materials address a wide range of stakeholders like science and technology (education) policy-makers and shapers (including politicians and the media), diplomats, senior military personnel, researchers and students of Chemistry/Science. The issue in this regard is not the diversity of stakeholders but the content and pedagogical requirements needed to address the diverse stakeholders. Some of these stakeholders are adults but others are young students, still some have scientific background but others not at all, and to make things more complex, some have background in the ethics of science and technology but others not at all. What is clear is that 'one size fits all' kind of educational material cannot work here. So what are the most plausible and yet cost-effective approaches at a financial crisis time that we are in now?

A related issue to the above ones is the choice of media for delivering the educational materials. As we know very well in Africa, particularly in the rural areas, the penetration of technology—let alone modern one—is very limited. So what are the most effective ways of reaching such large segments of the African population while using the education and outreach materials in relation to the CWC?

I understand that the answers to many of the issues raised above call for undertaking research in relation to education and outreach about the CWC. But I believe that many chemists and teachers could have specific/contextualized experiences in dealing with issues that I raised above even if those experiences could in a different field other than the CWC. It is also my belief that you will share with us your experiences so that we deal with the problems raised above collectively for the common goal addressing the ideals of the CWC. The African Journal of Chemical Education (AJCE) is ready to publish your voices in terms of research articles, feature articles, letters to the editor-in-chief, etc. It is also ready to devote a special issue to education and outreach related to the CWC if sufficient contributors are available.

REFERENCES

1. OPCW (2005). Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and n Their Destruction. The Technical Secretariat (English-Language Version).
2. Pearson, G.S. and Mahaffy, P. (2006). Education, Outreach, and Codes of Conduct to Further the Norms and Obligations of the Chemical Weapons Convention (IUPAC Technical Report). **Pure Appl. Chem.,** Vol. 78, No. 11, pp. 2169–2192.
3. Rappert, B., Chevrier, M. and Dando, M. (2006). In-Depth Implementation of the BTWC: Education and Outreach, Bradford Review Conference Paper No. 18.
4. Hay, A., Tarasova, N. Becker, E., Sharma, O., Robson, R. and Mahaffy, P. (2005). Educational material for raising awareness of the Chemical Weapons Convention and the multiple uses of chemicals. A Project submitted to IUPAC (Project No. 2005-029-1-050).

CHEMISTRY IN INDIGENOUS AFRICAN KNOWLEDGE AND TRADITIONAL PRACTICES[1]: REFLECTIONS ON A PERSONAL EXPERIENCE

Florence Ssereo
UNESCO, France
Email: f.ssereo@unesco.org

Note from the Editor-in-Chief

After office hours during a joint official mission out of our respective duty stations, my colleague Florence and I were talking about our past (mainly school time) experiences. Although I knew that Florence studied Chemistry in her country Uganda, I was impressed by the kind of personal experiences at home that led her to study Chemistry. I thus asked her to put those valuable experiences in writing so that I publish it in the AJCE.

Enjoy reading the essay below from her that combines Chemistry, women and indigenous knowledge and experiences in Africa. I also invite you to send your thoughts, reflections, research works and experiences in indigenous knowledge and Chemistry education in Africa [AJCE, 2(3), July 2012).

INTRODUCTION

The article you are about to read is a contribution to reflections on difficulties to interest and attract young people to study chemistry in post primary education. Through the story of my childhood experiences with my aunt I have attempted to answer the question ***"why did you choose to study chemistry in high school and university?"*** The article illustrates the importance

[1] *The author is Dr. Florence Ssereo, is a member of the chemical society. She holds a BSC in Chemistry/Biochemistry; a Ph.D in Social Sciences, and several post-doctoral diplomas in various disciplines. Currently works at UNESCO HQs as education programme specialist, in the section for teacher education and policy.*

of participatory learning, progression from the simple to the complex, the relevance and use of chemistry in life, the role of the adult as teacher, educator, and facilitator of learning, reference book for indigenous knowledge and use of chemistry in economic, social and cultural life.

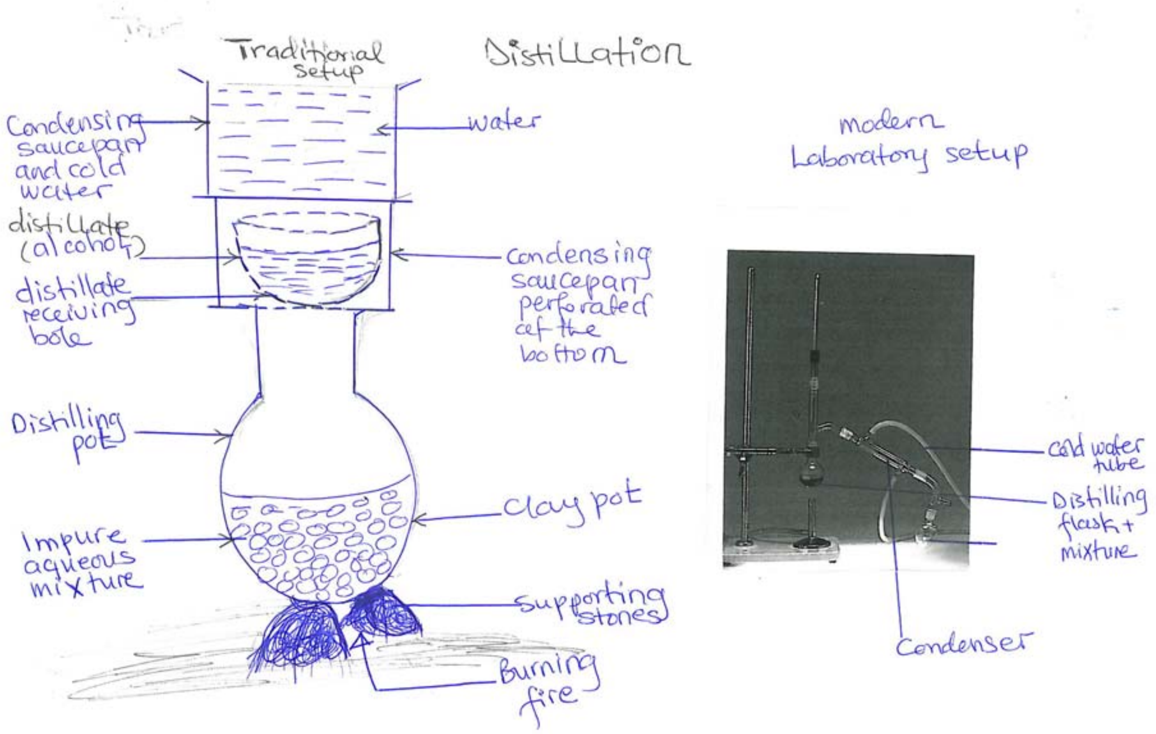
My discovery of chemistry dates back to my childhood and it relates to its use in daily life in the context of indigenous knowledge and its application. Ever since this discovery chemistry has been my best friend a much treasured souvenir from my early childhood past. Chemistry was not an abstract idea to me, rather a practice, knowledge about doing certain things, skills and attitude that includes observing things and reporting with accuracy what has been seen or felt as applied to real life situations. Doing it right led to earning money! I learned this definition of chemistry through the practices of my late aunt Ruzina, at the ages of 8-10 years before I joined secondary school, where I was formerly introduced to chemistry, consolidated my hence-on experiences and furthering my theoretical knowledge and discoveries in chemistry during my University studies, thus moving from real life chemistry to the abstract!

I vividly recall my first encounter with chemistry, it was in real life, participating in doing concrete things with my aunt Ruzina, an ordinary woman whose level of education was lower secondary (seven years of basic education). My first chemistry lessons were not in a classroom with a trained teacher. My aunt who never studied chemistry used it in her life to generate income and entertain social gatherings. She was a practical person, knowledgeable and patient educator, later becoming my role model. A non-alcohol drinker but she brewed the best *waragi* (the traditional alcohol); whose quality she controlled through burning small samples while the distillate was still very hot. To date she is remembered by the community as the best *waragi supplier at* social events (weddings, funerals and reconciliation ceremonies).

I was a curious child, full of questions yet she provided answers to my numerous questions, to me was extraordinary, the way she assembled her distillery intrigued me and further nourished my curiosity. I spent most of my early childhood years with my aunt, watching her in action, and obeying her orders. I was the young apprentice, she was the teacher.

The process of distillation of the alcohol*, waragi* from fermented "spoiled brown sour porridge" consisted of several steps. Step 1: Grinding into flour dried corn (maize); Step2:, Mingling the flour with a measured quantity of clean drinking water; Step 3: Fermentation for three weeks of the mixture in a big saucepan (100l); Step4: Drying in the sun of the fermented paste; Step5: Baking or grilling the semi-dried fermented flour over the fire in a big half-open pot; Step 6: Grinding of some dried germinated millet grains on a grinding stone to serve as yeast (catalyst); Step 7: Reaction: The baked paste is cooled, transferred into the reaction pot, the yeast is added to the pot and the pot is filled with clean drinking water. The reaction pot is placed in a corner of the kitchen near the traditional stove, the family cooking fire place, to ensure a regular warm temperature required for optimum action of the yeast (the catalyst). After 2 days the brown aqueous mixture tastes like sour porridge and may be drunk as such. Some adults preferred to drink this form of sour porridge, this serves as mid-reaction quality control testing. On the fifth day of the reaction, no more foam is observed. The yeast (catalyst) is exhausted and has become inactive, the mixture is considered ready for distillation.

Step8: Distillation phase, the equipment (see diagram below) consisted of a big boiling pot, an aluminum saucepan (30cm) is filled with cold water and placed on top of another aluminum saucepan (30cm) but porous (bearing several holes) at the bottom holding a clay bole, the distillate collector. The porous saucepan is placed on top of the pot half-filled with the brown aqueous boiling mixture. The pot is supported by three big stones, making the traditional stove, fed with fire from burning wood and twigs.



My job was to watch-over the setup; ensure that the fire burned in a regular manner to maintain a consistent temperature. The liquids in the boiling mixture reached boiling points at different temperatures, the evaporated liquid passed through the fine holes in the saucepan above and condensation was facilitated by the cold water in the second saucepan. The distillate was collected in the bole placed in the porous saucepan. Whenever the water in the condenser was hot, it was replaced by cold water and after three rounds, the setup was dismantled. The distillate bole was removed, the residue was removed and the boiling pot cleaned and a new aqueous mixture was poured into the boiling pot.

Step 9: Quality control: The distillate, while still very hot would be tested for quality. It was fascinating to watch my aunt pour a small portion of the distillate into a tiny clay bole, hold a burning match stick over the distillate. When it burned with a blue flame, she decided it was very good distillate (30-35%), and when it burned with a weak yellowish flame she said it was weak (15-20%), and she would either serve it free to relatives and friends or pour it back into the boiling pot. This was her quality control measure.

Step 10: Storage: The cooled distillate, the alcohol (waragi) would fill 3-4 clean bottles (75ml), ready for sale! Stronger the alcohol, on that burns with blue flames higher the price and the weaker the alcohol (burns with yellow flames) lower its price (half the price of the stronger). Then Step 8 to 10 is repeated until all the aqueous mixture is distilled.

The key chemical terms and concepts described are *distillation,* the separation of liquid mixture into its components on the basis of difference in boiling points. *Heat of condensation,* (expressed in kJ/mole), is the amount of heat that must be removed from a specific amount of vapor at its condensation point to condense the vapor with no change in temperature. This is the heat that heats up the cold water in the first saucepan in the traditional distillation setup. *Condensation* is the liquefaction of vapor/steam, which makes it possible to collect the distillate in the bole placed in the second porous saucepan in the traditional distillation setup and *evaporation* is the process of vaporization of a liquid, which makes it possible for the vapor or steam to pass through the fine holes in the second saucepan and condense into the distillate collector[2].

---

[2] *Sources and for further reading refer to:*
General Chemistry, 5th edition
Kenneth Witten, Raymond Davis, M. Larry Peck
Saunders College Publishing, 1996

IS THIS 'CHEMISTRY IN INDIGENOUS KNOWLEDGE' OR 'INDIGENOUS KNOWLEDGE IN CHEMISTRY'?

Whatever your answer, I later discovered that my aunt was a chemist, she used scientific knowledge inherited through her own mother from foremothers for generations. Without any prophesy she introduced me to my future profession, a contemporary chemistry teacher. When she wanted to teach me a trade, brewer of waragi for sale to earn a living, she increased my intellectual curiosity and the desire to study chemistry, investigate the continuum in knowledge-natural sciences, social and human sciences, and culture, economic and micro-finance. My aunt relied on chemistry in real life, applied general chemistry. Her knowledge and use of chemistry in daily life was part of her cultural intangible heritage, a traditional practice inherited from mother to daughter, which mean only women had the knowledge and skills to brew and distil alcohol, including for sale. Girls from her part of the world were initiated to the chemistry of brewing before marriage so that they would be financially independent from their husbands and be able to support their family.

My aunt had no problems answering my many questions, standing up to my curiosity as she believed she was teaching me a trade, how to make my own money when I grew up. Instead she initiated me to the study of chemistry, laying the foundations of my choice and study of chemistry and degree in Bachelor of Science in chemistry and biochemistry. I watched and participated in the practical exercises (experiments) conducted by my aunt in her kitchen with much pleasure, later practical classes of chemistry in the University were fun, I would enjoy my several hours in the chemistry laboratory conducting experiments, patiently observing, touching, feeling, smelling and reporting as accurately as possible.

As described above, in the 1970s I observed the use of fundamental chemical principles of fermentation, distillation, evaporation, condensation, heat transfer, cooling and collecting distillate, precautions and quality control as part of her indigenous knowledge, as inherited from my grandmother, from their foremothers. Likewise, I did my apprenticeship with my aunt. I watch her in action, imitated her, observed with fascination the display of skills of observation, discipline, precaution, attention, concentration and remedying and correction measures. At the age of 12 years I had memorized the process of distillation, the several steps that described preparation, reaction, distillation and post-distillation.

By the time I went to secondary school, I was motivated and interested in studying a subject that would help me to better understand and explain observations of scientific phenomenon made during my childhood and wanted opportunities to further the practices of my aunt based on indigenous knowledge. I was lucky to be able to study, be formally introduced to secondary education chemistry in year one, it was compulsory to study chemistry, physics, mathematics, geography and history, considered to be core subjects in the education system of Uganda in the 1970s. In the third year, students were invited to choose three science subjects, including biology, mathematics, and physical sciences (chemistry and physics) (science option) or history, geography and literature (arts option). I chose the science option, and studied physical sciences, biology and mathematics and at university level, chose to major in Chemistry, bio-chemistry. I was very happy, as I had wanted to study and understand sufficiently the theories and principles of distillation, evaporation, condensation, heat transfer through the evaporation-condensation process in order to teach it to others, interest other girls to study chemistry and bio-chemistry and I hope I have convinced you that chemistry is part of daily life and not something abstract.

Thus the reputation of chemistry as difficult among young people, its characterization "character assassination" as abstract or removed from real life are false. They may relate to difficulties in teaching due poor preparation of the teacher, inappropriate curriculum, absence of user-friendly instructional materials, outdated facilities and equipment for practical classes, theoretical teaching-learning processes, stereotyping and cultural prejudices, low budget allocation for pedagogical innovations and for ongoing research.

My knowledge and experiences have revealed to me that there is chemistry use in indigenous traditional knowledge as well as in modern scientific knowledge. Chemistry is interesting and made easy when teaching-learning processes are participatory, when teachers and learners are co-creators of knowledge, observe, record and explain what is observed together. When through research, investigation and discussion young students acquire scientific culture, provide answers to traditional practices in their community, such as how the traditional bread bakery works, why the traditional stove located eastwards or westwards near the kitchen door, why pawpaw leaves are used to wrap fresh meat where there is no refrigerator, why boiled drinking water is kept covered in a porous clay pot, why hand wash with ashes is effective in killing germs and why drink strong alcohol after eating raw meat?

Is the relation between indigenous and modern not a continuum in knowledge?

IMPACT OF THE CURRICULUM REFORM ON PROBLEM SOLVING ABILITY IN CHEMISTRY: AN EX POST FACTO STUDY ON CHEMISTRY EDUCATION STUDENTS

Dereje Andargie Kidanemariam
Debre Birhan University, Institute of Education, Ethiopia
Email: dereje_mariam@yahoo.com

ABSTRACT

An ex post facto study was conducted to examine the effect of the curriculum reform on 60 Dilla University chemistry education students' problem solving ability. The study shows that the curriculum reform that shifted university introductory courses of the old curriculum into preparatory school levels in the new curriculum significantly hampered students' problem solving ability. *[AJCE, 2(3), July 2012]*

INTRODUCTION

In dealing with the issue of problem solving orientation in chemistry education, we may need to first consider the larger question why we teach chemistry? There is a relationship between chemistry and everyday life. However, students' at all educational levels make little connection between chemistry that happens in the classroom and that happens outside of classrooms. Students perceive each chemistry topic or intellectual knowledge as a separate entity, which is detached from the physical world. However, intellectual knowledge is not separate from the physical world; rather it is symbolic and abstract representation of the physical world (1).

According to Krulik and Rudnick (2) the gap between chemistry classrooms and the outside world can be narrowed down by giving an emphasis on development of problem solving in chemistry and setting up a positive mood in the classroom. Likewise Soden (3, p.133) claims that "learning is problem solving". Therefore, teaching problem solving is teaching people how to learn, so is problem solving in chemistry education.

Kalbag (4) states that problem solving orientation in chemistry education has an importance in that problem solving converts information into knowledge. Kalbag further states that problem solving always produces a knowledge that is much more active and usable than information acquired in other ways (4). This can help not only to solve professional or life problems, but also to learn and convert information stored in memories into usable knowledge structures. And hence, problem solving orientation in chemistry education needs a critical concern at least at the higher education levels.

In 1994 the Federal Democratic Republic Government of Ethiopia has introduced a new Education and Training Policy which states that the objective of higher education is to produce problem solving professionals in their field of studies (5). More importantly, development of problem solving skills of teachers through a learner-centered approach and curriculum that integrates content and methodology has been the objective of teacher education (6). Following the new education and training policy the higher education curriculum has been reformed.

As a result of the curriculum reform the first year university introductory (general) courses of the old curriculum has been moved into preparatory schools. Consequently in the new curriculum, the first year university introductory courses of the old curriculum are taught to students within their two years stay in the preparatory schools (grades 11 and 12). Hence, the two year study in the preparatory schools is presumed to be equivalent with a one year study or the first year university courses of the old curriculum.

Upon completion of the first year introductory courses at preparatory schools (grade 12), students who scored the minimum pass mark (as decided by the Ministry of Education) are directly admitted to universities in different departments. Hence the study has been designed to investigate the impact of the new curriculum on students' chemical problem solving ability compare with the impact of old curriculum. The study was conducted while the old and the new curriculum were run in parallel.

THEORETICAL FRAMEWORK

Variables which determine problem solving ability

Frazer and Casey in Kornhouser (7) define problem solving in chemistry: as the result of application of knowledge and procedures to problem situations. And they propose four stages, such as definition of the problem, selection of appropriate information, combining the separate pieces of information and evaluation of the solution. Kornhouser (7) remarks that the best chance for success in chemical problem-solving rests on the combination of strong background knowledge of chemistry, good knowledge of problem solving strategies and tactics, and confidences. Similarly, many academics note that in any educational context and in life in general problem solving process is the interaction of factual knowledge, cognitive and meta-cognitive strategies, experiences, belief systems and social factors (8). Therefore, problem solvers need to posses well coordinated cognitive components of the three critical cognitive components of problem solving process: knowledge structure, cognitive functioning and belief system towards the task (9).

Chemical knowledge structure

Knowledge is one of our cognitive constructs that are necessary to consciously identify and solve problems. For instance chemistry problem solvers need to have chemistry knowledge. Many psychologists and researchers, working in problem solving, argue that problems never been solved in vacuum. Hence the problem solver should possess a background knowledge related to the problem at hand.

Academics such as Taconis, Ferguson-Hessler and Brockkp (10); Soden (11); Borich, McCormick, Tombari, and Pressley ([12]; and Bunce and Gabel (13) note that knowledge structure is a basic and a core components of problem solving that problem solver should posses to tackle problems in any professional area of life in general. Borich, McCormick, Tombari, and Pressley (12) assume that knowledge is a determinant of performance. They added that those who posses domain specific knowledge processes information efficiently than domain novices. Similarly Simon and Hayes in Bunce and Gable (13) remark that if one wants to solve a problem, there is no substitute for having prerequisite knowledge.

Studies conducted on college chemistry students show that using conceptual understanding is necessary for problem solving, and show that problem solvers based on conceptual understanding performs twice than algorithmic (traditional) problem solvers (13). For instance, Gabel and Bunce from their study on chemistry students' remark that in order to solve a chemistry problem in an acceptable manner, the problem solver must have both scientific and procedural knowledge. In this connection Taconis, Ferguson-Hessler and Brockkp presented a model (see figure 1 below.) that shows the basic role of scientific and procedural (skill) knowledge on learning cognitive tasks or problem solving in science (10). In sum, what studies on problem solving show is that, well grounded knowledge structure is a basic component of successful problem solving.

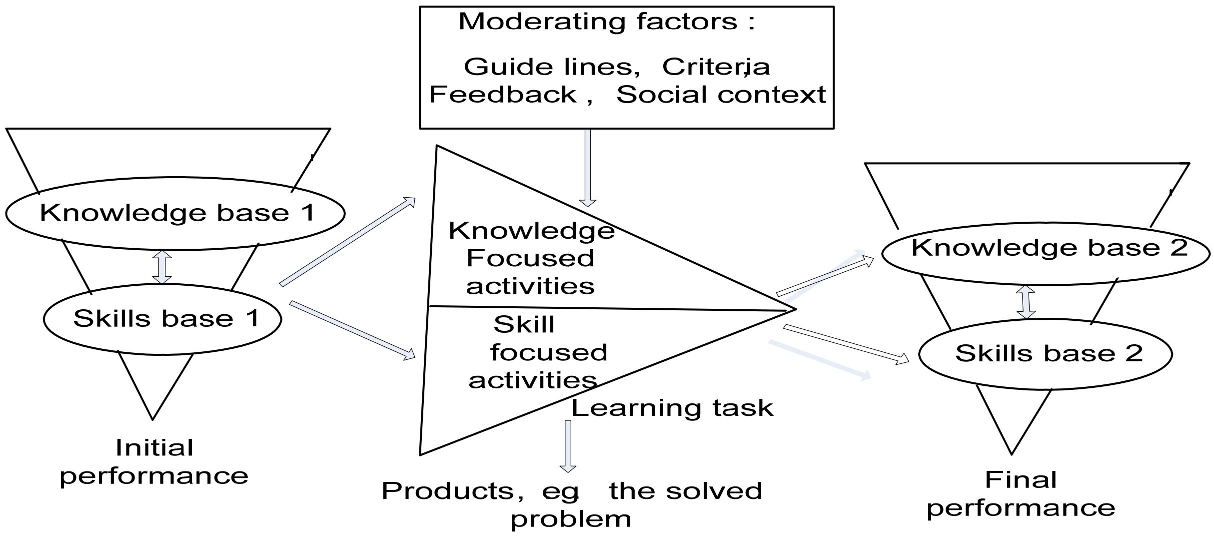


Figure 1. Basic view on learning to perform a cognitive task (10)

In light of this model (fig. 1), the moderating factors (or independent variables) and final performance (or dependent variables) of this study were:

1. Students origin and year level (i.e. independent variables), and
2. Students' problem solving ability (i.e. dependent variables).

Here students' origin refers to preparatory and freshman origin. Preparatory origin students' are those who attended university introductory courses in preparatory schools, but those who attended their introductory courses in Dilla University are freshman origin students.

Thus this study has been designed to determine the impact of origin and year level on problem solving ability of chemistry education students.

Knowledge structure of successful vs. unsuccessful problem solvers

Knowledge structure of successful problem solvers should be organized in terms of concepts, principles, rules, conditions and procedures Gable and Bunce (13) and Sugrue (9). Gable and Bunce , and Sugrue state that, if the knowledge structure of good problem solvers is well integrated, the triggering of one of the nodes (concepts) of the structure will activate the whole knowledge structure and hence process of accommodation will come into action. However, the knowledge structure of poor problem solvers is deemed to be fragmented and unconnected (9).

Assessment of knowledge structure

While we are talking about knowledge structure, it is about a way how domain specific knowledge structure is composed from facts, concepts and principles interlinked (chunked) into a usable forms of knowledge organization, eg knowledge structure about thermodynamics. Therefore assessment of knowledge structure involves the assessment of concepts, principles, and their interrelations, how concepts are linked to conditions and procedures (9).

RESEARCH OBJECTIVES AND QUESTIONS

The study has the following objectives:

1. Comparing problem solving ability of Chemistry Education students with reference to year level.
2. Comparing problem solving ability of chemistry education students with reference to their origin, i.e.
   a) Students who took their introductory courses in university (freshman origin students) with
   b) Students who took their introductory courses in preparatory schools (preparatory origin students).

The main research questions are:

1. Does the curriculum reform that moved an introductory university courses from university to preparatory schools have an impact on chemistry education students' problem solving performance in chemistry?
2. Does student's year level have an impact on chemistry education students' problem solving performance in chemistry?
3. Does the curriculum reform that moved an introductory university courses from university to preparatory schools have an impact on chemistry education students' problem specific and easily accessible knowledge structure?
4. Does student's year level have an impact on chemistry education students' problem specific and easily accessible knowledge structure?

RESEARCH METHODOLOGY

The study applied the proactive ex post facto research design. This design is selected for students' origin and year level are variables which cannot be manipulated. As a result the three groups of subjects were selected based on the preexisting independent variables: 1) origin: freshman origin and preparatory origin students, and 2) year level: third and fourth year students.

The population of the study was composed of groups of 46 third year freshman origin, 36 third preparatory origin, and 42 fourth year freshman origin chemistry education students of Dilla University. The freshman origin groups of students stands for the old curriculum students who attended their freshman courses in the colleges/or Universities. However third year preparatory origin students stands for the new curriculum students who attended their freshman/introductory chemistry courses in their two years stay at different preparatory schools.

For ease of analysis, preparatory origin group of students were grouped and recognized as a third year level students by counting their two years stay at preparatory schools as equivalent to one year stay at university and their two year study in the university. While this study was conducted both the third year preparatory and freshman origin students were at the same year level and attending the same chemistry courses.

By disproportionate stratified random sampling technique 60 subjects were selected from each stratum. That is 56 % (N=20) third year preparatory origin students, 43 %(N=20) third year freshman origin students and 48% (N=20) fourth year freshman origin students. From the total of four female students: two from third year and two from fourth year female students, three of them participated by their consent.

The purpose of this study was to explore if there is a problem solving ability difference among chemistry education students due to student year level and origin. As problem solving behavior is related to self efficacy beliefs and knowledge structure, two different corresponding instruments were designed to measure these variables.

This study used chemistry tasks to measure accessible and problem specific knowledge structure and problem solving behavior of students. According to Myer in Kirkley (14) problem solving is cognitive but it can be inferred from behavior and its result that lead to a solution. For instance knowledge is stored in mind in several forms: words and pictures for example. Moreover, Leithwood, Steinback, and Raum (15) discuss that knowledge goes beyond purely cognitive content implied by the term. This implicitly infers that knowledge structure and problem solving performance can be implied when the solver is working on tasks.

The tasks designed to illicit chemical knowledge structure and problem solving performance of students is closely related to everyday life and include one algorithmic and five conceptual problems (Appendix). The tasks were designed from topics in the introductory courses selected by the following criteria:

a. The topics are taught for target groups (i.e. third and fourth year chemistry education students).
b. Common topic to the target group and are identified by mastery objectives to be achieved
c. The topics are more closely related to every day life.

Moreover, each of the problems was designed to exhibit problem solving behavior and elicits propositional and procedural knowledge required in solving the problems.

Initially four algorithmic and seven conceptual problems were designed. Then the problems have been evaluated by chemistry lecturers and master students using the following criteria:

a. Stated in clear and simple languages
b. Authentic and practically important and application problems
c. Appealing to all three groups of students
d. Solvable using a variety of solution strategies; and
e. The difficulty of the problems in terms of the number of principles required to solve

And then based on the comments received from one analytical and one inorganic chemistry lecturers of Dilla University, and one analytical and one environmental chemistry master students of Addis Ababa University the instruments were revised and reduced in to six. The tasks/problems were integrated with instructions that demand students to set goals before engaging in solution process, to write the conditions (givens), constraints in solving and then to write every step that the solver used to solve each problem. Finally the six problems which met the criteria were administered. In addition to the instructions provided in print form, verbal instructions were given on how to work on each problem.

The numerical data collected on problem specific and easily accessible knowledge structure (ASPK) and problem solving performance (PSB) are analyzed using mean, standard deviations; two-sample independent t-test, one-way ANOVA and post hoc tukey test by using statistical analysis software origin 7. Two-sample independent t-test, one-way ANOVA and post hoc tukey test statistical techniques were applied to see if there were a statistical significance difference observed in APSK and PBS among third year students, third year preparatory and freshman origin students, and fourth years students.

Task analysis is one of the important steps of problem solving investigation. Sugrue (9) notes that most problems solving investigations and reasoning begins with a task analysis. Task analysis is not a formal and standard set of procedures but the type of analysis will vary depending on the theoretical framework of the researcher as well as the extent and sophistication of the available research and theory. However, outcome of this analysis is an explicit statement of all cognitive activity that occurs from initial presentation and final solution of a problem.

Therefore, in view of this idea, in order to examine status of cognitive components of problem solving ability: 1) problem solving behavior/performance (PSB), and 2) the accessible problem specific knowledge structure (APSK) of chemistry education students on the task were analyzed using scoring grid (see appendix B). The scoring grid were developed from the literature, such as Sugrue (9). The scoring grid for each problem ranges from 0 to 4. The total score of each student's performance on the task is obtained by adding the scores obtained for each task/problem. Therefore, the total scores of each student's PSB and APSK on the task/problem could range from 0 to 24. Based on the scoring model explanations students were classed into the following three problem solving performance (PSB) categories:

	Category of problem solving behavior	Total score on the task/problem
1	Poor problem solvers	[0,6]
2	Moderate problem solvers	(6,18]
3	Successful problem solvers	(18,24]

Similarly using the scoring model explanations used students were classed into the following three problem specific and easily accessible chemistry knowledge structure (APSK) categories:

S. No.	Category of students APSK used for solving the task/problem	Total score on the task/problem
1	No APSK or fragmented APSK with specific misconception	[0,6]
2	Partial and Fragmented APSK	(6,18]
3	Active and well integrated APSK	(18,24]

RESULTS AND DISCUSSIONS

Demographic descriptions

60 subjects were participated in the study: 57 male and 3 female. Out of these, 40 were third year students (i.e. 20 preparatory and 20 freshman origins) and 20 were fourth year students.

Table 1: Demographic data

Sample characteristics		Frequency (N)	Percent (%)
Gender	Female	3	5
	Male	57	95
Year level and origin	a. Third year freshman origin	20	43
	b. Third year preparatory origin	20	56
	c. Fourth year freshman origin	20	48
Tasks are from chemistry topics we have learned already	a. Yes	57	95
	b. No	3	5

As it can be seen from table 1, 3 of the 57 participants responded that the tasks were not from topics they were being taught. This implied that the knowledge component of problem solving can be suffered for only few groups of students.

1. *Does the curriculum reform that shift an introductory university course from university into preparatory schools have an impact on chemistry education students' problem solving performance in chemistry*?

Null hypothesis (H_0): There is no statistically significantly different problem solving performance in chemistry among third year freshman origin, preparatory origin and fourth year freshman origin chemistry education students. H_0: $\mu_1 = \mu_2 = \mu_3$

Alternative hypothesis (H1): There is statistically significantly different problem solving performance in chemistry among third year freshman origin, preparatory origin and fourth year freshman origin chemistry education students.

H1: $\mu1 \neq \mu2 \neq \mu3$, or $\mu1 \neq \mu3$, or $\mu1 \neq \mu2$, or $\mu2 \neq \mu3$.

A one-way ANOVA comparison test on μ_1, μ_2, and μ_3 shows that the population means were significantly different from the test difference (0), $F(2,57)=13.36$, $p=4.57$, at $\alpha=0.05$ level. This result indicates that students' origin has a significant effect on problem solving performance. The mean values for problem solving performance of fourth year freshman origin (M3), third year freshman origin (M2), and third year preparatory origin students (M1) indicate that the problem solving performance is higher for freshman origin students than for preparatory origin students ($M_3 = 12.07$, $SD_3 = 4.05$; $M_2 = 12.79$, $SD_2 = 4.19$; $M_1 = 5.36$, $SD_1 = 3.07$).

In order to locate the significantly different population means, a post hoc multiple comparison, Tukey test was applied.

Table 2: Results of means comparison using Tukey at test α=0.05 level

Students origin and year level	Mean(M)	Difference between means	Simultaneous confidence intervals		Significant at α=0.05 level
			Lower level	Upper level	
4th year 3rd year preparatory origin 3rd year freshman origin	12.07				
	5.36	6.71	2.91	10.51	Yes
	12.79	0.714	4.28	2.85	No
3rd year preparatory origin 3rd year freshman origin	5.36 12.79	-7.42	11.22	-3.62	Yes

As it can be seen from table 2, the means comparison using Tukey test at α=0.05 level showed that there was a significant difference between the population means of third year preparatory origin (μ_1) and mean of third year freshman origin (μ_2); the mean of third year preparatory origin (μ_1) and mean (μ_3) of fourth year freshman origin students. In short $\mu_1 \neq \mu_2$ and $\mu_1 \neq \mu_3$ are significantly different at α=0.05. However, there was not statistically significant difference between mean of third year freshman origin students (μ_2) and mean of fourth year freshman origin students (μ_3) , at α=0.05. The result indicates that both freshman origin students' (i.e. fourth year and third year) problem solving performance is significantly different from preparatory origin students' problem solving performance. But third year freshman and fourth freshman year students' problem solving performances do not differ significantly. This result shows the possibility that the overall difference in problem solving performance in chemistry is because of students' origin (i.e. due to the shift of university introductory courses in the old curriculum in to preparatory school levels in the new curriculum).

2. *Do students year level has an impact on chemistry education students' problem solving performance in chemistry?*

Null hypothesis (H_0): There is no statistically significantly different problem solving performance in chemistry among third year and fourth year freshman chemistry education students. H_0: $\mu_4 = \mu_3$

Alternative hypothesis (H_1): There is statistically significantly different problem solving performance in chemistry among third year and fourth year freshman chemistry education students. H_0: $\mu_4 \neq \mu_3$

An independent two sample t-test at α=0.05 was used to determine if there would be any significant difference between problem solving means of third and fourth year students.

Table 3: Two sample independent t-test on problem solving means of third and fourth year chemistry education students (α=0.05)

Year level	N	Mean(M)	Standard deviation (SD)	Standard error (SE)	t	p-value
Fourth year	20	12.07	4.05	1.08	1.57	0.125
Third year	40	9.52	5.25	1.05		
Mean difference		2.55				

As it can be seen from table 3, the sample mean (M_3) and standard deviation (SD_3) of problems solving score of fourth year students was M_3= 12.07, SD_3 = 4.05 and mean (M_4) and standard deviation (SD_4) of third year students was M_4 = 9.52, SD_4= 5.25.

A two sample independent t-test shows that there is not statistically significant difference between the population means of fourth year and third year students from the test difference, ($\mu_4 - \mu_3 = 0$),(t(58) =1.57, p=0.125). This result indicates that year level has not a significantly effect on students' problem solving performance. Studies show that basic problem specific domain knowledge determines successful problem solving (7, 10, 12). However, this implies that year level in both old and new curriculum is less likely to improve students' problem specific domain knowledge structure.

3. *Does the curriculum reform that shifted an introductory university courses, from university to preparatory schools has an impact on chemistry education students' problem specific and easily accessible knowledge structure?*

Null hypothesis (H_0): There is no statistically significance difference in problem specific and easily accessible knowledge structure among third year preparatory origin, third year freshman origin and fourth year freshman origin chemistry education students. H_0: $\mu_1 = \mu_2 = \mu_3$

Alternative hypothesis (H_1): There is statistically significance difference in problem specific and easily accessible knowledge structure among third year preparatory origin, third year freshman origin and fourth year freshman origin chemistry education students. H_1: $\mu_1 \neq \mu_2 \neq \mu_3$, or $\mu_1 \neq \mu_3$, or $\mu_1 \neq \mu_2$, or $\mu_2 \neq \mu_3$.

A one-way ANOVA comparison test on μ_1, μ_2, and μ_3 shows that the population means were significantly different than the test difference (0), $F(2,57)=11.64$, $p=1.26$, at $\alpha=0.05$ level. This result indicates that students' origin has a significant effect on accessible and problem specific knowledge structure of students. The means value for accessible and problem specific knowledge structure of fourth year freshman origin (M_3), third year freshman origin (M_2), and third year preparatory origin students (M_1) indicates that the accessible and problem specific knowledge structure is higher for freshman origin students than for preparatory origin students ($M_3 = 15.79$, $SD_3 = 4.35$; $M_2 = 16.12$, $SD_2 = 2.49$; $M_1 = 10.45$, $SD_1 = 2.25$).

To determine/locate statistically significant different means of the population parameters Tukey test was applied at $\alpha=0.05$.

Table 4: Third year preparatory origin, third year freshman origin, and fourth year students usable and problem specific knowledge structure mean comparisons, ($\alpha=0.05$)

Students origin and year level	Mean (M)	Difference between means	Simultaneous confidence intervals		Significant at $\alpha=0.05$ level
			Lower level	Upper level	
4th year 3rd year preparatory origin 3rd year freshman origin	15.79				
	10.43	5.33	2.14	8.52	Yes
	16.21	-0.429	-3.42	2.56	No
3rd year preparatory origin 3rd year freshman origin	10.45 16.21	-5.76	-8.95	-2.57	Yes

As it can be read from table 4, Tukey test indicated that there is a statistically significant difference between the population means of fourth year freshman origin and third year preparatory origin students; third year freshman origin and third year preparatory origin students. In short $\mu_3 \neq \mu_1$ and $\mu_2 \neq \mu_1$ are significantly different at $\alpha=0.05$. However, there was not statistically significant difference between the means of fourth year freshman origin students (μ_3) and third year freshman origin students (μ_2), at $\alpha=0.05$.

This result indicates that both freshman origin students' (i.e. fourth year and third year) problem specific and easily accessible chemistry knowledge structure is significantly different from preparatory origin students' problem specific and easily accessible chemistry knowledge structure. But freshman origin (i.e. third year freshman origin, fourth year freshman origin) students' problem specific and easily accessible chemistry knowledge structure do not differ significantly. This result shows the possibility that the overall significant difference in problem specific and easily accessible chemistry knowledge structure is more probable to be due to students' origin (i.e. the shift of university introductory courses of the old curriculum into preparatory schools of the new curriculum).

4. *Do students year level has an impact on chemistry education students' problem specific and easily accessible knowledge structure?*

Null hypothesis (H_0): There is no statistically significance difference in problem specific and easily accessible knowledge structure between third year and fourth year chemistry education students. H_0: $\mu_4 = \mu_3$

Alternative hypothesis (H_1): There is statistically significance difference in problem specific and easily accessible knowledge structure between third and fourth year chemistry education students. H_0: $\mu_4 \neq \mu_3$

An independent two sample t-test at α=0.05 was used to compare if there would be any statistically significant difference between problem specific and easily accessible knowledge structure means of third and fourth year students.

Table 5: Two sample independent t-test and summary statistics on fourth and third year students' APSK

Year level	N	Mean	SD	SE	t	p-value
Third year	40	13.68	3.74	0.75	-1.59	0.120
Fourth year	20	15.79	4.35	1.16		
Mean difference		-2.11				

As can be seen above, the mean (M_3) and standard deviation (SD_3) of problem specific and easily accessible knowledge structure score of fourth students was M_3 = 15.79, SD_3 = 4.35 and mean (M_4) and standard deviation (SD_4) of third year students was M_4 = 13.68, SD_4= 3.74.

A two sample independent t-test shows that there is not statistically significant difference between the means of fourth and third year students from the test difference ($\mu_4 - \mu_3 = 0$), t (58) =1.57, p=0.125). This result indicates that year level has no significant effect on students' problem specific and easily accessible chemistry knowledge structure on topics being taught.

CONCLUSIONS

From the current study the researcher concluded that

1. The curriculum reform that moved university courses into preparatory schools has failed to achieve the objective of teacher education that aims to produces successful problem solvers.

2. The new curriculum has not been as impactful as the old curriculum that offered introductory courses in the first year university study in developing well integrated problem and domain specific chemical knowledge among chemistry education students.
3. The problem solving ability of chemistry education students' is more likely to be affected by curriculum reform than the number and year level of students attended in the university.

REFERENCES

1. Robert, M.G. (1977). The conditions of learning, 4 Edition (New York: Holt Rinehart and Winston Inc.).
2. Krulik, S., and Rudnick, J.A. (1987). Problem solving: A handbook for teachers, 2 ed, Allyn and Bacon, Inc.: 7 Wells Avenue, Newton, Massachusetts.
3. Soden, R. (1994). Teaching problem solving in vocational education (London: Roultedge).
4. Kalbag, S.S. (1987). Problem solving orientation in education. Journal of Education and Social Change, 127-140.
5. Ethiopia, F.D.R.G.o. (1994). Education and training policy **1**ed, St. George priting press: Addis Ababa.
6. Ministry Of Education, M. (2003). Teacher education system overhaul handbook (T.E. Programe, ed.): Addis Ababa.
7. Kornhouser, A. (1992). Some methods in teaching chemistry: Four studies. In Teaching School Chemistry, Waddington, ed. (New Delhi: Sterling Publishers Private Limited).
8. Taylor, K.L., and Dionne, J.-P. (2000). Accessing problem-solving strategy knowledge: The complementary use of concurrent verbal protocols and retrospective debriefing. Journal of Educational Psychology *92*, 413-425.
9. Sugrue, B. (1994). Specifications for the design of problem-solving assessments in science, Center for Research on Evaluation, Standards, and Student Testing, Los Angeles.
10. Taconis, M.G.M., Ferguson-Hessler, H., and Broekkamp (2001). Teaching science problem solving: An overview of experimental work. Journal of Research in Science Teaching *38*, 442-468.
11. Sodon, R. (1994). Teaching problem solving in vocational education (London: Roultedge).
12. Borich, G.D., McCormick, C., Tombari, M.L., and Pressley, M. (1997). Educational psychology: learning, instruction, assessment (New York, NY, England: Longman Publishing/Addison Wesley L.).
13. Gabel, D., and Bunce, D. (1994). Research on problem solving: Chemistry. In Handbook of Research on Science Teaching and Learning, D. Gabel, ed. (New York: Simon and Schuster Macmillan).
14. Kirkley, J. (2003). Principles for teaching problem solving, Indiana University, PLATO learning, Inc.
15. Leithwood, K.A., Steinback, R., and Raum, T. (1993). Supper intendents' group problem solving process. Educational Administration Quartely *29*, 364-391.

APPENDICES

I. Task from some selected content areas of chemistry

Instruction: dear student there are six chemistry problems designed for you. Please attempt each of the problems. The problem(s) might have come across you in your everyday life. While you are attempting to solve each of the problems, do not use separate paper, please. Before you are going to engage in solving the problems, please restate each of them what it asks you in your own words. Your answer will remain strictly confidential and WILL NOT affect your grade.

1. If a reaction that is exothermic can be controlled catalytically, then by regulating the amount of the catalyst available perhaps the rate of release of heat from the reaction can be regulated. How? Justify your answer.
2. Assume you are living in a rural area where there is no electricity and refrigerator, but you want to supply a coca cola below the surrounding temperature. How can you cool this soft drink? Suggest methods and explains every of your steps.
3. Rain water in Norway and German tastes sour. What do you think the reason? What possible solution that doesn't harm their economy would you suggest to reduce the problem?
4. The salinity of a solution is defined as the grams of total salt per kilogram of solution. An agricultural chemist uses a solution whose salinity is 36.0 g/kg to test the irrigating farm land with high salinity river water. The two solutes are NaCl and Mg_2SO_4, and there are twice as many moles of NaCl as Mg_2SO_4. What masses of NaCl and Mg_2SO_4 are contained in 1.00 kg of the solution?

5. Suppose you are in need of AgCl, but only crystals of AgNO3 and NaCl are available in your chemical store. How would you obtain AgCl? Propose ways with detail explanations.
6. Suppose, while you are cooking food with high nutritive value which can only boil at high temperature, water would bubbled and finished up before the food is well cooked. What could be the possible reason? Propose your possible procedure to cook it sufficiently.

II. Scoring grid for problem solving performance (task analysis)

weight	criteria	attributes
0	No correct solution	- Blank space, I don't know, - Incorrect understanding of the problem with in correct solution, determine the goal state constraints to reach to the solution
1	Partially correct with some mistakes	- Correct understanding (mental representation of the problem with incorrect solution)
2	Partially correct solution	- Correct understanding of the problem and solving some components of the problem, such as using logical methods, appropriately applying the concepts and principles.
3	Correctly solving the problem but with incomplete correct solution	- Correct understanding of the problem, - Using logical methods of attacking the problem, - Applying the relevant knowledge structure and algorism to the problem but not completed.
4	Successfully solving the problem	- Correct understanding of the problem, - using correct and logical methods of attacking the problem - using relevant knowledge structure and algorithms to the problem, giving the ultimate solution of the problem

III. Scoring grid for problem specific and easily accessible chemistry knowledge structure exhibited on chemistry tasks

weight	criteria	attributes
0	No accessible and problem related knowledge structure to solve it	- Blank , I don't know - Incorrect knowledge: wrong understanding of concepts and principles - I do not understand
1	Partially accessible problem related knowledge structure, but with some misconceptions	- Knowledge of general problem (task) related concepts, principles but with some misconceptions - Lacks problem specific concepts to directly attack the problem
2	Partially accessible knowledge structure related to the problem/task	- General knowledge of concepts and principles but no link is made between knowledge and the problem. - The concepts and principles were fragmented, lacks problem specific concepts and principles to directly attack the problem
3	Accessible knowledge structure but with some deficit to successfully solve the problem	- Knowledge of general concepts and principles related to the task - The links made between concepts and principles with the problem/task - Knowledge of some problem specific concepts and principles to directly attack the problem but with some fragments
4	Active and well integrated knowledge structure to successfully solve the problem	- General and specific concepts directly related to the problem - Integration of concepts and principles with concepts involved in the problem - Knowledge of correct algorithms correctly solves the problem

OPTIMIZATION OF FLAME ATOMIC ABSORPTION SPECTROMETRY FOR MEASUREMENT OF HIGH CONCENTRATIONS OF ARSENIC AND SELENIUM

Hossain Md Anawar
Okavango Research Institute, University of Botswana, Botswana
E-mail: anawar4@hotmail.com

ABSTRACT

High concentrations of As and Se in mining wastes covering a large area in the mine operating countries present a threat to public health, environment and ecological diversity in different countries. Therefore, a rapid, cost-effective, affordable and routine analysis is needed to monitor the preliminary contamination levels in these countries. In order to achieve this goal, this study has optimised the flame atomic absorption spectrometry (FAAS) to determine the high concentrations of As and Se using standard samples. The best result of the calibration curve fit (R^2 = 0.959) was found for the standard As concentrations of 0, 5.61, 11.22, 16.83 and 22.45 mg/L; and indicated the very strong linearity of calibration. This procedure allowed a rapid determination of As from minimum 4.462 mg/L to higher concentrations without sample pre-treatment. Besides As, this method successfully measured Se concentrations from minimum 1.0 mg/L to higher concentrations. The results showed that FAAS can measure lower concentrations of Se than As. Therefore, this method can be widely applied in different countries for determination of As and Se in environmental samples with high concentrations for the rapid, cost-effective and routine analysis, who can not afford the expensive methods such as ICP-MS, ICP-AES, ICP-OES etc. The study finally suggests the implications of the findings to chemical education. *[AJCE, 2(3), July 2012]*

INTRODUCTION

Due to the high toxicity and carcinogenic activity, arsenic (As) has achieved great notoriety (1) and public health concern. Although selenium (Se) is an essential micronutrient for humans, animals and some plants (2), its safety margin between its nutrient and toxic doses is very narrow; and levels as low as 0.01 mg/L can cause deformation and death of wildfowl. Recommended guideline limits of As are 0.01 mg/L for drinking water, and 50 mg/kg for agricultural soil (3). Extremely high concentrations of As, occasionally Se, up to some hundreds or thousands of mg/kg are found in As-rich sulfidic mining waste derived from As, antimony, gold, tin, tungsten, mercury, base metals, uranium, coal, sulphur and other mining activities, as for example, abandoned Machavie Gold Mine near Potchefstroom, South Africa (4), although its crustal average is only 2 mg/kg (3). And subsequently, it is released from the solids through the various processes of dissolution, redox reactions, and adsorption–desorption, because all of which control its behaviour in the environment (5). Therefore, it is very important to find out a rapid, low cost and appropriate method for routine analysis of As and Se concentration in order to monitor the preliminary contamination levels in mining affected areas.

A large number of analytical techniques are being used to quantify the concentrations of trace metals in different environmental samples. For example, inductively coupled plasma mass spectrometry (ICP-MS), inductively coupled plasma atomic emission spectrometry (ICP-AES) or inductively coupled plasma optical emission spectrometry (ICP-OES), flame atomic absorption spectrometry, hydride generation and graphite furnace- atomic absorption spectrometry are widely used for analysis of As, Se and other metals in different types of samples (6). Atomic absorption spectrometry (AAS) is an easily affordable, sensitive, well established and well-known technique for the determination of As, Sb, Se and many other elements using either flame or hydride generation (HG) or electrothermal atomization (7). The AAS method using flame is rapid, precise and applicable to about 67 elements. However, the sensitivity of this technique is lower with limits of detection (LOD) in the range of mg/L and needs higher amount of samples when compared to hydride generation or electrothermal AAS. Graphite furnace or electrothermal methods of analysis on the other hand are slower and less precise; however, these are more sensitive and need much smaller samples. In AAS, the flame atomiser and furnaces (electrothermal atomiser) that generate a temperature in the range of 1500 to 3000ºC are the most common methods of atomisation. Graphite furnace AAS and HGAAS have been widely used for determination of As and Se in different environmental samples including water, soil, sediment, plant, fish, petroleum products, wine, beer, mining wastes, and any other types of inorganic, organometallic and biological samples, because both of these methods are the most sensitive techniques with LOD in the range from µg/L to ng/L (8).

GFAAS offers high selectivity, simplicity, low tolerance to complex matrices, and relatively high cost of equipment for routine analysis (9]. By contrast, FAAS offers simplicity, and relatively low cost of equipment for routine analysis (10). Direct analytical techniques are preferred for routine analysis over those that require significant sample preparation; and FAAS is offering the possibility for direct analysis. However, both GFAAS and HGAAS need complex sample preparation, and matrix modification is usually necessary in GFAAS to remove matrix effects (11) for determination of the accurate elemental concentrations in the samples. For the past decade, many studies have been performed in order to understand the behaviour of As, Sb, Bi, Pb, Ag, Cd, Cr, Hg, and Ni in presence of different matrices and modifiers as well (12-14). However, even after several years of development, GFAAS or ETAAS has not been widely applied for the direct determination of above metals and metalloids in different environmental samples. In the recent years, the interference problems in ETAAS have been reduced by improving the background correction techniques. However, there are still interferences in the determination of As by ETAAS (15).

HGAAS presents very low LOD for these elements in many kinds of matrices, including environmental and biological samples (16). An important advantage is related to the analyte separation from the matrix components, offering considerable suppression of matrix effects. However, this technique is prone to some drawbacks that could occur in the process of generation and release of the hydride, during the transport up to the atomization cell, and in the gas phase during the atomization step (16).

Given the above complexity of sample preparation, removal of interferences, cost and time of measurement, therefore, it is important to develop a suitable and affordable proper method of low cost for fast, accurate and routine analysis of a large number of environmental and mining samples in different countries. In order to determine As in complex residues from gold mining, Pantuzzo et al. (17) optimised the PerkinElmer (Norwalk, Connecticut, USA) model A300 FAAS equipped with a deuterium background correction and a specific As electrodeless discharge lamp. Flame AAS can directly measure the high concentrations of As and Se in microwave assisted acid digest samples, clear solutions, without any further modification. Therefore, the aim of this study was to evaluate the adequacy and appropriateness of FAAS for As and Se analysis in standard samples with very high concentrations. For this optimisation study, TG 990 FAAS equipped with a deuterium background and hollow cathode lamp (HCL) was used.

MATERIALS AND METHODS

Preparation of As and Se standard solution

The standard stock solutions for As(V) (231 mg/L) were prepared in 100 mL calibrated flask by dissolving $Na_2HAsO_4{\cdot}7H_2O$ in acidic high purity deionized water (0.1% nitric acid). Standard solutions of As(V) were prepared by stepwise dilution of a 231 mg/L standard solution just before use. Diluted working solutions were prepared daily by serial dilutions of this stock solution. Three different As concentration ranges of working standard solutions used in this study were (1) 0, 1.15, 2.31, 4.62 and 9.24 mg/L, (2) 0, 0.558, 2.231, 4.462 and 11.154 mg/L, and (3) 0, 5.61, 11.22, 16.83 and 22.45 mg/L. The standard stock solutions of Se(V1) (100 mg/L) were prepared in 100 mL calibrated flask by dissolving Na_2SeO_4 in acidic high purity deionized water (0.1% nitric acid). Diluted concentrations of Se(V1) were prepared daily by dilutions of this stock solution just before use. The Se concentrations of working standard solution were 0, 1.04, 3.14, 5.24, 10.48 and 20.97 mg/L.

Instrument and operating conditions for As and Se

Arsenic and Se were measured by FAAS. The operating conditions for As and Se measurement are described in Table 1. The burner parameters and the burner position were optimized daily to have the As and Se HCL radiation at target point.

RESULTS

Measurement of As

The analysis of As standard samples demonstrated that the solutions of concentrations like 4.62 and 9.24 mg/L produced the positive signals with the absorbance of 0.037 and 0.061, respectively, whereas the As concentrations of 1.15, and 2.31 mg/L did not show any positive signal. The statistical analysis of the results found for all five As concentrations of 0, 1.15, 2.31, 4.62 and 9.24 mg/L presented the calibration curve fit of R^2 = 0.85 indicating the poor linearity of calibration. The second set of standard As solutions, as for example, 0, 0.558, 2.23, 4.46 and 11.154 mg/L demonstrated the calibration curve fit of R^2 = 0.903 indicating the good linear relationship. The standard As solutions of 0.558, and 2.231 mg/L did not produce any positive signal; however, As concentrations of 4.462 and 11.154 mg/L did strongly. Arsenic standard solutions with concentrations more than 4.462 mg/L produced always good signal, accurate and re-producible results. The calibration curve fit was R^2 = 0.959 for the standard As solutions of 0, 5.61, 11.22, 16.83 and 22.45 mg/L indicating the very strong linearity. The As standard solutions of 5.61, 11.22, 16.83 and 22.45 mg/L produced positive signal. Some standard samples of As concentration less than 5.61 mg/L did not produce positive signal indicating that the results of As concentrations less than 5.61 are not accurate and re-producible, but As concentrations more than 5.61 mg/L produced positive signal, and re-producible results.

Measurement of Se

For the Se standard solutions of 0, 1.04, 3.14, 5.24, 10.48 and 20.97 mg/L, the calibration curve fit was R^2 = 0.999, that indicated the very strong linearity. The Se standard solutions of concentrations such as 1.04, 3.14, 5.24, 10.48 and 20.97 mg/L produced good positive signal. Some standard samples of Se concentration less than 1.0 mg/L produced negative signal indicating that the Se concentrations less than 1.0 mg/L can not be measured by FAAS. However, Se concentrations more than 1.0 mg/L produced positive signal, and re-producible results.

DISCUSSIONS

Although we know that the environmental samples contain high levels of As and Se, but it is essential to determine their concentrations before we perform the remediation activities and waste treatment. Therefore, this method will be beneficial to determine their concentrations in the environmental samples and mining wastes before we perform the remediation activities. The objective and purpose of this study was to develop the analytical method by the optimization of flame atomic absorption spectrometry and determine the high concentrations of arsenic and selenium in the standard samples. Therefore, we did not use this optimized method to the real samples. If this method is used to determine more than 22.45 mg/L As and 20.97 mg/L Se, as for example 100 mg/L or 1000 g/L, then the sample solutions should be diluted according to the operating ranges.

IMPLICATION FOR CHEMISTRY EDUCATION

The finding of this study has practical implications for undergraduate and postgraduate degree, because atomic absorption spectroscopy is a compulsory course in the undergraduate and postgraduate education of Chemistry in general and Analytical Chemistry in particular. Flame atomic absorption spectroscopy is a common course for the laboratory of instrumental analytical chemistry in the university. For Chemistry Education major students in my University, teaching and science come together in a fluid way, with excellence in both areas. Many universities' chemistry programs encourage the students to be active in research starting in the freshman year. Atomic absorption spectrometry is used in the representative research works of Analytical Chemistry in the university. As a Chemistry teacher in a university, we can use the findings of this study in teaching-learning program, because our optimized method is a rapid, cost-effective, affordable and routine analysis technique to analyse arsenic and selenium in the environmental samples, food, soil and water. I recommend the chemistry curriculum developers (in a university or others) to incorporate this method in the teaching and instrumental analytical chemistry.

CONCLUSIONS

This procedure allows a rapid determination of As and Se from minimum 4.462 mg/L and 1.0 mg/L, respectively, to higher concentrations without sample pre-treatment and stabilization of the analyte for a sufficiently long period of time between sample preparation and the analysis, minimizing errors due to analyte losses. The results showed that FAAS is more sensitive for Se and can measure lower concentrations of Se than those of As. It is worth mentioning that the use of FAAS for determination of As and Se in the environmental samples, mining wastes, mining contaminated water and soils from different African countries (South Africa, Ghana, Zambia, Zimbabwe, Botswana, Democratic Republic of Congo, etc.) and other countries of the world will greatly reduce the cost and time for routine analyses.

REFERENCES

1. P.O. O'Neill, Arsenic (1995). In: Alloway BJ (ed) Heavy metals in soils, 2nd edn. Blackie, London, pp 106–121.
2. C. Galinha, M.C. Freitas, A.M.G. Pacheco, J. Kameník, J. Kučera, H.M. Anawar, J. Coutinho, B. Maçãs, A.S. Almeida (2011). Selenium in cereal plants and cultivation soils by radiochemical neutron activation analysis. Journal of Radioanalytical and Nuclear Chemistry (online available by Springer).
3. H.M. Anawar, A. Garcia-Sanchez, A. Murciego, T. Bujolo (2006). Exposure and bioavailability of arsenic in contaminated soils from the La Parrilla mine, Spain. Environ. Geol. 50, 170–179.
4. P. Aucamp, A. van Schalkwyk (2003). Trace element pollution of soils by abandoned gold mine tailings, near Potchefstroom, South Africa. Bull. Eng. Geol. Env. 62, 123–134.
5. S.R. Al-Abed, G. Jegadeesan, J. Purandare, D. Allen (2007). Arsenic release from iron rich mineral processing waste: Influence of pH and redox potential. Chemosphere 66, 775–782.

6. Z. Ajtony, N. Szoboszlai, E.K. Susko, P. Mezei, K. Gyorgy, L. Bencs (2008). Direct sample introduction of wines in graphite furnace atomic absorption spectrometry for the simultaneous determination of arsenic, cadmium, copper and lead content. Talanta 76, 627–634.
7. G.G. Bortoleto, S. Cadore (2005). Determination of total inorganic arsenic in water using on-line pre-concentration and hydride-generation atomic absorption spectrometry. Talanta 67, 169–174..
8. E. Becker, R.T. Rampazzo, M. B. Dessuy, M.Goreti R. Vale, M.M. da Silva, B. Welz, D. A. Katskov (2011). Direct determination of arsenic in petroleum derivatives by graphite furnace atomic absorption spectrometry: A comparison between filter and platform atomizers. Spectrochim. Acta Part B 66, 345–351.
9. R.Q. Aucélio, A.J. Curtius (2002). Evaluation of electrothermal atomic absorption spectrometry for trace determination of Sb, As and Se in gasoline and kerosene using microemulsion sample introduction and two approaches for chemical modification, J. Anal. At. Spectrom. 17, 242–247.
10. B. Welz, M. Sperling (1999), Atomic absorption spectrometry, 3 rd edn. Wiley-VCH, Weinheim.
11. Z. Kılıc, E. Kenduzler, O. Acar (2002). Determination of lead and copper in chewing gum samples by electrothermal-flame atomic absorption spectrometry using various chemical modifiers and arsenic by hydride generation. Food Chem. 77, 85–92.
12. L. Pszonicki, J. Dudek (1999). Modifier effects in the determination of arsenic, antimony and bismuth by electrothermal atomic absorption spectrometry, J. Anal. At. Spectrom. 14, 1755–1760.
13. A.B. Volynsky, S. Akman, C.E. Dogman, U. Koklu (2001). Application of colloidal palladium modifier for the determination of As, Sb and Pb in a spiked sea water sample by electrothermal atomic absorption spectrometry. Spectrochim. Acta Part B 56, 2361–2369.
14. M.A. Castro, C. Garcıa-Olalla, L.C. Robles, A.J. Aller (2002). Behavior of thorium, zirconium, and vanadium as chemical modifiers in the determination of arsenic by electrothermal atomization atomic absorption spectrometry. Spectrochim. Acta Part B 7,1-14.
15. N. Matti, P. Paavo, P. Juha (2003). Microwave sample-digestion procedure for determination of arsenic in moss samples using electrothermal atomic absorption spectrometry and inductively coupled plasma mass spectrometry. Anal. Bioanal. Chem. 357, 673–678.
16. J. Dědina (2007). Atomization of volatile compounds for atomic absorption and atomic fluorescence spectrometry: on the way towards the ideal atomizer, Spectrochim. Acta Part B 62, 846–872.
17. F.L. Pantuzzo, J.C.J. Silva, V.S.T. Ciminelli (2009). A fast and accurate microwave-assisted digestion method for arsenic determination in complex mining residues by flame atomic absorption spectrometry. J. Hazard. Mat. 168, 1636–1638.

Table 1. Operational conditions employed in the determination of As and Se by FAAS

Parameter	As	Se
Wavelength (nm)	193.7	196.1
Spectral bandwidth (nm)	0.4	1.0
Lamp	As HCL	Se HCL
Lamp current	8 mA	10 mA
Oxidant (air) L/min	17	17
Fuel (acetylene L/min)	2.2	2.2
Signal processing	Peak area (absorbance)	Peak area
Replicate	3	3
Background correction mode	Deuterium	Deuterium
Atomization site	Quartz tube atomizer (QTA)	QTA

LABORATORY ACTIVITIES AND STUDENTS PRACTICAL PERFORMANCE: THE CASE OF PRACTICAL ORGANIC CHEMISTRY I COURSE OF HARAMAYA UNIVERSITY

Belay Tafa
Arbaminch University, College of Natural Science, Department of Chemistry, Ethiopia
Email: belay799571@gmail.com

ABSTRACT

The major objective of this study was to offer an overview of the current situation in the course practical organic chemistry I of Haramaya University. All first year second semester chemistry students, laboratory instructors and Practical Organic Chemistry I course material were involved as the main source of data. The main instruments used to collect the necessary data were questionnaires and content analysis of the course material. Observation was another instrument of data collection. Qualitative and quantitative methods were employed to analyze data. The results indicated that the majority of the activities have lower inquiry level of one and the dominant practical work identified was demonstration type activity. Moreover laboratory instructors and students ranked the most important objective of the manual—to demonstrate materials taught in lecture—least. Based on these findings certain recommendations were forwarded. *[AJCE, 2(3), July 2012]*

INTRODUCTION

Laboratory activities have had a distinctive and central role in the science curriculum and science educators have suggested that many benefits mount up from engaging students in science laboratory activities (1, 2, 3, 4, 5, 6, 7, and 8). Over the years, many have argued that science cannot be meaningful to students without worthwhile practical experiences in laboratory. Unfortunately the term laboratory or practical have been used, too often without precise definition, to embrace a wide array of activities. Lots of arguments have been raised in the past to give justification or rationale for its use. Even though laboratory sessions were generally taken as necessary and important, very little justification was given for their inclusion (5, 8, 9 and 10). Some laboratory activities have been designed and conducted to engage students individually, while others have sought to engage students in small groups and in large-group demonstration setting.

Both the content and pedagogy of science learning and teaching are being analyzed, and new standards intended to shape and refresh science education are emerging (11, 12). Teacher guidance and instructions have ranged from highly structured and teacher centered to open inquiry. The terms have sometimes been used to include investigations or projects that are pursued for several weeks, sometimes outside the school, while on other occasions they have referred to experiences lasting 20 minutes or less.

The National Science Education Standards (11) and the 2061 project (13) reaffirm the conviction that inquiry in general and inquiry in the context of practical work in science education is central to the achievement of scientific literacy. Inquiry-type laboratories have the potential to develop student's abilities and skills such as: posing scientifically oriented questions

(14 and 15), forming hypothesis, designing and conducting scientific investigations, formulating and revising scientific explanations and communicating and defending scientific arguments.

Chemistry is essentially a laboratory activity oriented subject. No course in chemistry can be considered as complete without including practical work in it. Laboratory activity, here, is used to describe the practical activities which students undertake using chemicals and equipment in a chemistry laboratory. The original reasons for the development of laboratory work in chemistry education lay in the need to produce skilled technicians for industry and highly competent workers for research laboratories (16 and 17).

STATEMENT OF THE PROBLEM

Laboratories are one of the characteristic features in the sciences at all levels. It would be rare to find any science course in any institution of education without a substantial component of laboratory activity. Even though the instructional potential of the laboratory is enormous (5), most practical activities in higher education are by nature illustrative or demonstrative (8). Too often they emphasize the acquisition of observational skills; and allow students to see the concept dealt in action and relate theory more closely to reality (10, 18 and 19).

It is important to think about goals, aims and objectives in the context of laboratory work. Today, many chemistry first degree graduates are not employed as bench chemists in industry (20 and 21) and their reaction to practical work is often negative as a result they are not effective in laboratory work and this may reflect a student perception that there is lack of clear purpose for the experiments: they go through the experiment without adequate stimulation (22 and 23).

Science teaching in universities is often criticized for being prescribed, impersonal, lacking an opportunity for personal judgments and creativity. Science has become reduced to a series of small, apparently trivial, activities and pieces of knowledge mostly unrelated to the world in which students are growing up and inhibiting to their developing personalities and aspirations (15, 21).

Scholars (21) identify three distinct types of practical work:

1. *Experiences*, which are intended to give students a 'feel' for observable fact;
2. *Exercises*, which are designed to develop practical skills and techniques; and
3. *Investigations*, which give students the opportunity to tackle more open-ended tasks like a problem-solving scientist (11)

Some also classify practical works in to four major types: exercises, experiences, demonstrations and investigations. Each of these types of practical has its own place in science teaching. Field works are likely to include aspects of all these functions (36). Table 1 gives the definition of each practical work and this list also serves as the classifying scheme.

Table 1: Types of practical works**:**

Exercise	To develop practical skills
Experiences	To gain experience of a phenomenon
Demonstration	To develop a scientific argument or cause an impression
Investigation	Hypothesis – testing: to reinforce theoretical understanding. Problem solving: to learn the ways of working as a problem solving scientist.

Source: (39) effective science teaching – developing science and technology education series

Depending on their purposes and the degree of detailed control exercise by the staff over students' activities, laboratory courses classified in to three main ways: controlled exercises, experimental investigations and research projects. According to these authors, these are some of the strategies which may provide opportunities for the detection of various educational aims in the laboratory teaching (9).

A number of researchers (10, 24) analyzed different types of laboratory investigations based on the level of openness and the demand for inquiry skills. Through a revised form, typical laboratory lesson was compared with that of a typical investigation carried out by a scientist in terms of who does what and he concludes that what students are actually doing in a typical laboratory is like technicians and not like scientists. It was suggested that this openness can occur at different stages of an investigation: in the problem to be solved; in the planning and operation of the investigation; and in the possible solutions to the problems. Based on this, some produce a four-way classification of investigations, depending on whether each stage is open – that is left to the students to decide or closed (10).

At level zero all the problems, procedures, and conclusions are given and hence there is no experience of scientific inquiry. At this level, one may find exercises involving practices in some techniques and/or confirmation where the answer is already provided to the students. They may provide opportunities for students to learn accuracy in the process of trying to replicate a known answer. In level one, both problems and procedures are given and they have to collect data and draw the conclusions. In level two, only the problem is given and the student has to design the procedure, collect the data and draw conclusions. These are called investigative practical. In level three, the student has to do everything beginning with problem formulation up to drawing of conclusions (9, 10, and 24).

In this research report it is important to understand that following terms are defined as follows. *Chemistry laboratory activities* refer to the practical activities which students undertake using chemicals and equipments in a chemistry laboratory (2, 20). *Inquiry level* is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results (25). *Objective in laboratory instructions* is a term which refers to what to be taught, who is to be taught to, by what means, and most importantly, what are the intended outcomes (22and 26).

RESEARCH OBJECTIVES AND QUESTIONS

In light of the above rationale of problems and facts inherent to laboratory activities, this study was initiated to challenge the laboratory activities and practices in chemistry laboratories with a special reference to Practical Organic Chemistry I offered by the Department of Chemistry at Haramaya University. Practical Organic Chemistry I is a one credit-hour course given to first year second semester chemistry students. Students spend three hours per week, which is a total of thirty six hours in a semester, in the laboratory and what they perform in this part of the course has a value of one credit hour. This course was selected because it was the only practical course given to students at the time when this research was being done.

The major objective of this study was to offer an overview of the nature of Practical Organic Chemistry I offered by the Department of Chemistry in Haramya University. The specific objectives of the study were:

1. To evaluate the types of objectives of the selected activities
2. To assess the inquiry levels assigned to the laboratory tasks
3. To measure the relevance of the activities in terms of the recent concern, students' interest and instructors reaction to what should be the objectives of the laboratory tasks.

In order to achieve these objectives, the study posed the following research questions:

1. What types of objectives are served by the activities included in the course material?

2. What types of laboratory activities dominate the course Practical Organic Chemistry I?
3. How do students and laboratory instructors react to what should be the objectives of the laboratory tasks?
4. What levels of inquiry are assigned to the laboratory tasks?
5. What are students actually doing and how well are their performance in Practical Organic Chemistry I laboratory sessions?

RESEARCH DESIGN AND METHODOLOGY

This study was undertaken at Haramaya University, located in east Hararghe Zone of Oromia Regional State, 525 km from Addis Ababa/Ethiopia, which has both applied chemistry and chemistry education programs. To the best of my knowledge no similar study has been done so far in the University. And the course was selected for it was the only practical course at the time (second semester) the research was being done.

This research attempted to study the nature of practical organic chemistry laboratory activities presented in Practical Organic Chemistry I course of Haramaya University together with students' practical performance and laboratory teachers' perceptions to what should be the objectives of practical courses in chemistry.. To this effect a descriptive research method was employed to conduct the study.

It is thus important to note that the scope of this study was limited to Practical Organic Chemistry I. So some generalization made based on the results of this study may have limitations in their application to other practical courses in the University and beyond.

The major research design employed was descriptive research. Descriptive research, sometimes known as non-experimental or co-relational research, involves describing and interpreting events, conditions or situations of the present. It describes and interprets what is. In other words, it is primarily concerned with the present, although it often considers past events and influences as they relate to current conditions (27). More specifically, descriptive research is concerned with conditions or relationships that exist, opinions that are held, processes that are going on, effects that are evident, or trends that are developing. Descriptive research can use qualitative or quantitative methods to describe or interpret a current event, condition or situation.

Qualitative researcher studies things in their natural settings to make sense or interpret phenomena in terms of the meanings people attach to them. Best and Kahn (27) suggested that the in- depth detailed description of events; interviews and others make qualitative research very powerful because it is believed that it is sensitive to temporal contexts in which the data are to be collected. Moreover, the qualification of actions, ideas, values and meanings through the eyes of participants is better than quantification through the eyes of an outside observer.

This study was more characterized by these attributes of the qualitative paradigm. Thus, it evaluated the objectives and the inquiry level assigned to the laboratory activities of the course manual. Moreover it measured the relevance of the activities and students and instructors reactions to what should be the objectives of practical activities in chemistry. In fact, the investigation also includes personal observation of the way practical organic chemistry activities were carried out in the laboratory.

Descriptive survey method was also employed to make quantitative studies. This method was selected because it was helpful to show situations as they currently exist (28). Moreover, it is economical and rapid and turnaround the data collection and identification attributes of a large population from a small group of individuals (29). Quantitative study also seeks to make researcher invisible and to remove any influence that the researcher might have on the research findings in the interest of objectivity.

Therefore from the whole students of the Department of Chemistry almost all first year second semester students (178 out of 184) who were doing Practical Organic Chemistry I and all laboratory instructors (n = 11) in the Department were included in this survey.

The intended information for this study was acquired through direct observation, document analysis and questionnaires. In qualitative study, data are collected from in-person interviews, direct observations and written documents such as private diaries. On top of this Wellington (30) mentioned that questionnaire are also important to collect data in qualitative study. The data for this study were collected from first year organic chemistry laboratory course material and curriculum, students taking practical organic chemistry I course and laboratory instructors. Moreover, the researcher was frequently observing the practical session of the course practical organic chemistry until sufficient data were obtained. The data were collected using the instruments discussed below.

Direct observation is most useful to collect natural data. Therefore, observation is the major means of data collection used by the qualitative researchers (31). It refers to actively, carefully and consciously describing what people do. During the study, the researcher observed almost all (10 out of 11) the practical sessions while the students were conducting the activities. This helped the researcher to answer questions related to students' practical performance in the laboratory like whether or not they were mixing chemicals which are already prepared by someone else, whether they can use apparatuses by themselves, whether they can assemble instruments by themselves, etc.. All observations were made using an observation checklist. (See Appendix-III)

A review of contents under each practical activities of the concerned course was made from relevant documents and curricular materials. Documentary sources in data collection helped to crosscheck the objectives stated in the documents against real objectives of practical activities in chemistry in particular and in science education in general. The documents used were curriculum and the course manual, and the analysis helped to know the objectives of the course, to identify the objectives type and then to evaluate their levels.

Questionnaires were another tools used to collect relevant information from the instructors and the students in this research. The researcher preferred close ended questionnaires because it was easier to handle and simple for respondents to answer and fill within short time. Two sets of questionnaire were prepared focusing on the aim of science laboratory and students' experiences of practical work in the course Practical Organic Chemistry I. Questionnaire one (with the list of aims for laboratory) was given to the students and laboratory instructors to rank the list of aims from the most important to the least important. Questionnaire two was given to students to react to the statements about what they did during their Practical Organic Chemistry I laboratory sessions.

Since the number of activities suggested in the course manual were manageable (n=84), all were considered in the study. Moreover, the same thing was done for the students taking the course who were (n=178) and all laboratory instructors (n=11) were taken as another important sources of information.

It was stated that data analysis consists of categories such as tabulating, testing or otherwise, recombining both qualitative and quantitative evidences to address the initial propositions of the study (32). To answer the research questions of this study, therefore, the data gathered were analyzed using both qualitative and quantitative approaches as indicated in the research design above.

Scholars (33) have shown that data analysis in qualitative studies basically involves in word argumentations than in numerical explanations. It is an ongoing activity that takes place during data collection, devising of categories and the building of theories. Hence, the data gathered from the students taking the course Practical Organic Chemistry I through observations and content analysis were analyzed qualitatively.

The data collected through closed ended questionnaires from laboratory instructors and students were analyzed quantitatively. One of the questionnaires provided to the students was developed using five point Likert-scales. The five points of scales were weighed according to the degree of agreements. The scaling procedures were adopted as (SA) – Strongly Agree; (A) – Agree; (Und) – Undecided; (DA) – disagree and (SDA – Strongly Disagree. To know the answers of the research questions, the collected data were analyzed by properly classifying, tabulating and calculating statistical values used for making conclusions.

Content analysis (sometimes called textual analysis when dealing exclusively with text) is a standard methodology for studying the contents of communication. Authorities in this field conceptualized content analysis as the study of recorded human communications, such as books, websites, paintings and laws (34); as any technique for making inferences by objectively and systematically identifying specified characteristics of messages (35). Practical Organic Chemistry I course manual and the course curriculum of the University were subjected to a content analysis. Based on the research objectives, a widely employed content analysis scheme developed by Woolnough and Tamir (10, 36) was employed to analyze the types of practical work and the degree of inquiry level.

RESULTS AND DISCUSSIONS

Analysis of the Objectives of the Laboratory Manual

Much discussion today surfaced concerning the need to specify goals, aims and objectives for courses in higher education, especially to laboratory teaching (9). The statement of aims and objectives, in any course has importance for they provide significant implication as to how the course should be planned and structured. Most agree that when planning a course, care should be taken to ensure the consistency of course aims with that of the more specific objectives and the kind of experiences provided to serve the objectives (9).

In this study, a close observation of the course curriculum objectives with that of the major objectives of the manual does not reveal consistency. Those objectives of the course that bring round to practical organic chemistry was to familiarize students with basic practical skills and, therefore, were not consistent with the objectives of serving to strengthen the theoretical part of the course, which was the objective of the manual. It does seem very important that, for practical work to be effective, the objectives should be well defined. As it is indicated in (37) when planning a course it is crucial to state clearly the intended objectives: what to be taught, and most importantly, what are the intended outputs of the course in a very clear way.

According to (9) undergraduate activities generally have two major purposes: they should give the student an opportunity to practice various inquiry skills, such as planning and devising an experimental program to solve problem, and an investigational work, which involves individualized problem solving, which is highly motivational especially if the student develops a sense of ownership for the problem.

Through the analysis of the lesson tasks, it was discovered that the most emphasized objective of the laboratory work was as stated by the manual. Most lessons were demonstrative by nature. About seven out of twelve lessons were primarily illustrative and no lesson was identified primarily targeted to help students apply scientific reasoning, to test hypothesis, to formulate hypothesis and to work out problems which are another important aims for involvement of laboratory activities in any science education.

According to Hegarty (38), to realize outcomes that focus on scientific method requires the provision of experience in real investigations. Students should have experiences in seeing problems and seeking ways to solve them (when students themselves design experimental procedures), interpret data, make generalizations and build explanatory models to make sense of the findings, etc., which are nonexistent in the manual.

The concern of most of the laboratory lessons of the manual, as shown in Table 6 below, has been identified as the acquisition of basic organic chemistry concepts. This was manifested through a close relationship between the content of the course and the students' task in the laboratory. Such traditional view of science in school has exposed many of the students to failure and frustration (18). Apart from this they were identified as reasons for students' failure since they emphasized practical work as means of enhancing conceptual learning rather than acting as a source for the learning of essential skills. The most dignified aim of the manual, to devote laboratory lessons follow closely the theoretical part, clearly illustrate its assigned task: to make practice accommodating to theory.

Table 2: The Emphasized Aims in the Course Manual

Ex. No.	Laboratory Lessons	Aims for Practical Organic Chemistry I
1	Re crystallization	To familiarize students with basic practical skills
2	Determination of melting points and simple distillation	To familiarize students with basic practical skills
3	Fractional distillation	To familiarize students with basic practical skills
4	Steam distillation	To familiarize students with basic practical skills
5	Survey of some functional groups	To strengthen the theoretical part of the lesson
6	Stereochemistry	To strengthen the theoretical part of the lesson
7	Preparation of aspirin	To strengthen the theoretical part of the lesson
8	Preparation of soap	To strengthen the theoretical part of the lesson
9	Chromatography	To strengthen the theoretical part of the lesson
10	Proteins and carbohydrates	To strengthen the theoretical part of the lesson
11	Qualitative organic analysis part I	To strengthen the theoretical part of the lesson
12	Qualitative organic analysis part II	To strengthen the theoretical part of the lesson

Level of Inquiry Associated with the Activities in the Laboratory Lessons

Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas. Understanding of the process of scientific inquiry could perhaps be developed using a variety of teaching approaches. Laboratory work can play an important role in developing students' understanding of the process of scientific inquiry, their intellectual and practical skills (39).

Based on the procedures identified in the literature part, the degree to which students make decisions about the problem, the procedures and/or the conclusions, all activities were analyzed to determine their level of inquiry.

Table 3: Summary of the Inquiry Level of the Activities

Inquiry Level Index of the Activities	**Number of Practical Activities**	**Percent**
0	34	40.47%
1	49	58.33%
2	1	1.19%

Level one exercises together with level zero exercises, are commonly known as ‘controlled exercises’, ‘wet exercises’, ‘recipes’ and ‘cook books’ (9). They do not involve students in an inquiry experiences except in the sense of consciously ‘copying’ an investigation conducted by other scientists (see Appendixes IV for some examples from the manual).

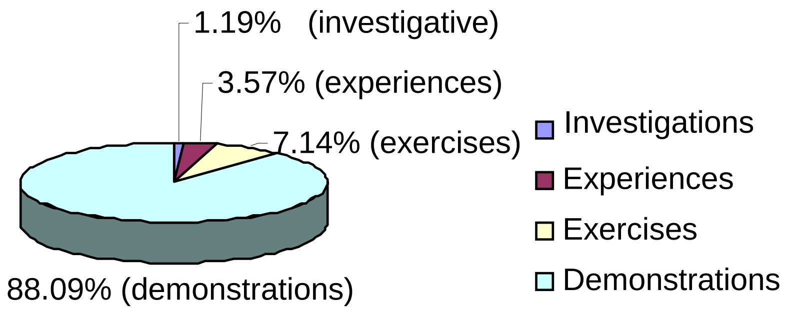
As shown in Table 3 above, 98.8% (83) of the laboratory work is devoted to the two lower levels, namely level 0 where the problem, the material needed, the procedures to follow, what type of data to collect are all given to the students who already know what the results will be or what to conclude and level 1 where the student is given the problem, the material and procedures to follow along with what type of data to collect but not the conclusion. Students make few decisions other than deciding whether they got the right information. There is only one simple activity, in the whole manual, having the Inquiry Level Index of two where the students are given the problem and there is no practical with the inquiry level index of three where the students formulate the problem, methods of gathering data relative to the problem, the outcome and conclusion they generate. For instance, the second activity in Appendix IV was classified as level 1 because it does not involve the student in designing the material and method to be used, but only to draw a conclusion.

As it is stated in Tamir (10), the main criticism of practical work in science education has been its sole emphasis on the lower levels. Students' failure to see the connections between what they actually do and the theory, and the place of laboratory in the larger context of the scientific enterprise are included in the censure (10). On top of this Herron (24) also reveals that even those curricula that claim to be inquiry-oriented have a significant portion of the laboratory exercises devoted to the low-level inquiry. The inclusion of exercises at an inquiry level 0 and 1 can be justified based on the view that students' first need is to have the basic skills and techniques necessary for carrying out the rest of practical science (9). It is not good, on the other hand, to devote the whole laboratory courses to confirmation of chemical content by denying students from being engaged in real problem solving investigation.

Types of Practical Work in the Course Manual

Based on a review of the literature, the content of each practical activity was analyzed in order to determine their type. About 84 discrete laboratory works were identified in the manual (see Appendix v). As shown in Figure 1, students spend much of their laboratory time performing demonstration activities (88.09%, 74) followed by exercises (7.14%, 6) and experiences (3.57%, 3) activities. The principal learning outcome of demonstration activities is to help the student grasp the theoretical understanding of the course.

Figure 1: Summary of Types of Practical Activities



Demonstration activities are primarily targeted to illustrate a particular concept, law, or principle which has already been introduced by the teacher and allow students to see the concept in action. Hence, they always target at relating theory more closely to reality. They can be taken as activities done by the instructor or activities done by students, given a detailed procedure to follow. Only 1.19% (1) of the laboratory activity is investigative. Investigative practical work gives freedom to students to choose their own approaches to the problem. This result is generally consistent with the objective of the manual—to strengthen the theoretical part of the course (2).

To sum up, almost all the suggested activities (98.8%) are controlled exercises for they are characterized by detailed experimental procedures and a known destination. According to Boud (9), these activities are the major emphasis of the early stages of undergraduate programs.

Students' Reactions to Practical Organic Chemistry I Work

One of the questionnaires distributed among the students was lists of statements related to their experiences in Practical Organic Chemistry I laboratory activities. They were asked to what extent they agreed or disagreed to a statement, on a five point Likert scale. Their response is summarized in Table 4.

Table 4: Mean student response to laboratory activity in Practical Organic Chemistry I

No.	Item	Mean response
1	The opportunity given to plan my own experiment is very satisfying	**2.75**
2	Clear instructions are given about the experiment before doing the practical activities	**4.52**
3	Standard experiments, written up correctly, give confidence to continue with chemistry	**4.66**
4	Organic Chemistry laboratory should be about learning to do science through scientific investigations	**3.21**
5	It is easy to grasp the aim and point of what I am doing and the importance of every laboratory activities	**2.66**
6	I feel most confident when the chemistry lessons were well structured and student directed	**4.65**
7	I appreciate the opportunity if the teacher lets me plan my own activity.	**4.83**

As shown in Table 4, the students responded above average for most items. However, it was identified that students look difficulty to grasp the aim and understand the importance of the activities. Further it was found more satisfying and gave confidence if the lessons were well structured and student directed. On top of these most students wish organic chemistry laboratory to be a place where they could practice scientific investigations

Students Performance in the Laboratory

As it is stated in different science education literatures a pre laboratory exercise is a short task or experience to be completed before the actual laboratory is carried out. Its fundamental aim is to prepare the mind for learning (4). Pre laboratory exercise can reduce the information load for students. Furthermore as it is explained in Carnduff and Reid (19), pre laboratory exercises are able to stimulate the student think through the laboratory work, with a mind prepared for what will happen and encourage them to recall or find facts such as structures, equations, formulae, definitions, terminology, physical properties, hazards or disposal procedures.

As part of this study the researcher was observing each laboratory session while the students were doing the experiments. In all the experiments there were no pre laboratory exercises so the students were not doing this. Apart from this, the data obtained from the laboratory session observation revealed that students were not taught how to set up the instruments that they are going to use to carry out the experiments. They did the experiments following the procedure given, by the already set up instruments. This indicated that they are needed only to record the data obtained from the experiments without having any knowledge about the instrument being used and even how to assemble it in their future career. Morholt, (16) says this type of laboratory activity does not want students to develop knowledge about instruments in a laboratory. As he further explains teacher's duty must be to explain his students about the apparatus whenever a student is required to make use of a piece of apparatus for the first time.

In addition, observation in this study showed that the laboratory works were done in teams of three and four students. This framework of the group may allow the students for a variety of interactions such as

- Opportunity to discuss, to consult with one another and to criticize and be criticized
- Increased efficiency by division of labor
- Opportunity to compare results and to interpret data within the group

The disadvantage, on the other hand, is it restricts individuals to be engaged in reviewing the literature, in deciding a suitable number and range of reading or observation, hypothesizing, planning experiment, collecting and processing data, drawing inferences and conclusion and writing a report by his interest.

Apart from this, the researcher did not observe any student planning to use suitable equipment and using information from previous work to guide their plan. They were simply following directions asking whether they are getting the right answer, to write a formal laboratory report than discussing what was done. This implies that if an individual is asked to gather a certain number of data and then forced to conclude something from the obtained data, the student begins to jump to conclusion from limited data.

Students' and Instructors' Ranking of Lists of Objectives of Laboratory Activities

The other questionnaire distributed among students and laboratory instructors consisted of lists of aims of laboratory in science education and asked them to rank these lists of aims from the most important to the list important according to their interest. And their responses were summarized as shown in Table 5.

Unlike the laboratory manual both instructors' and students' reactions to the major objectives of laboratory were found to be different. As shown in Table 5, both laboratory instructors and students were consistent in ranking the first and fourth most important objectives: a chemistry laboratory should intend to learn basic practical skills (item 4 in table 5) and to develop scientific reasoning (item 2), respectively.

Table 5: Aims ranked from highest to lowest by instructors and students

NO.	Item	Rank given by most instructors	Rank given by most students
1	To improve mastery of the subject matter	Eighth	Tenth
2	To develop scientific reasoning	Fourth	Fourth
3	To demonstrate materials taught in lecture	Ninth	Eighth
4	To build up practical skills	First	First
5	To design experiments to test hypothesis	Third	Sixth
6	To interpret experimental data	Second	Third
7	To promote interest in chemistry	Tenth	Ninth
8	To formulate hypothesis	Sixth	Fifth
9	To work out problems	Fifth	Seventh
10	To introduce equipment and develop observational skills	Seventh	Second

The major objective of the manual, that is, to demonstrate the material thought in class (item 3), was ranked ninth by instructors and eighth by students. Moreover, the role of practical work in developing interest in chemistry (item 7) was rated least by both laboratory instructors and students.

SUMMARY AND RECOMENDATIONS

The major objective of this study was to offer an overview of the current situation in the course Practical Organic Chemistry I in Haramaya University. All first year second semester chemistry students, laboratory instructors and Practical Organic Chemistry I course material were involved as the main source of data. The main instruments used to collect the necessary data were questionnaires and content analysis of the course material. Observation was also another instrument of data collection.

Qualitative and quantitative methods were employed to analyze data. The data gathered from the students taking the course Practical Organic Chemistry I through observations were analyzed qualitatively where as the data gathered from questionnaires and content analysis were analyzed qualitatively and quantitatively.

Based on the basic research questions, the findings of this study are summarized as follows.

- The response to each question was given by the manual in almost all activities. The majority of the activities have the inquiry level of one. They comprises 58.33%, followed by level 0 inquiry index (40.47%) and with only 1.19 % level two inquiry index activities.
- The dominant practical work identified was demonstration type. It comprised 88.09% of the practical work included in the manual with 3.57% experience practical, 7.14% exercise practical and only 1.78 % investigative type.
- Once students have the data collected they write up formal laboratory report rather than discussing what was done. Apart from this students were not giving due attention to the instrumentation and the way experiment is conducted.
- Most students think that the way objectives of the experiments are written is not clear to understand. Moreover, they face difficulty in understanding the importance of every laboratory activity.
- Students and instructors agreed that the most important objectives of a Chemistry laboratory work should be targeted in helping students to learn basic practical skills. Both groups ranked the most important objective of the manual, to demonstrate materials taught in lecture, least.

In light of the findings and discussions made in the previous pages the following recommendations are forwarded:

- Each activity should be revised by deciding who is making the decisions: the teacher, text or the student. There should be activities designed for goals other than teaching students particular skills. Hence beside their role of strengthening the theoretical parts, other aims like to help students apply scientific reasoning, to test hypothesis, to formulate hypothesis and to workout problems should be included.
- Procedures need to be changed by taking a level 0 activity and making a few changes to make it more like a level 1 activity. Progressively changes should be made in the whole activities students do so that over the course of time students will move from doing level 0 activities to doing activities that seem more like level 1, 2 or 3 activities. By then, they are figuring things out for themselves, interpreting results, perhaps even repeating procedures. In short they will be thinking the way scientists do about what they are doing.
- When students are doing laboratory exercises in a group, it would seem reasonable to pool the class data after enough measurements or observations and have the entire class discuss the observable trends rather than have each group generalize from their limited data.
- Depending on the particular goal of the laboratory and the prevailing local context of the organic chemistry course, different activities (like demonstration, experience, exercise and investigative) should be designed to accommodate the different levels of difficulty and guidance.
- Since student participation in enquiry, in actual collection of data and analysis of a real phenomenon are essential components of the enquiry curriculum it should be considered in designing the laboratory work in the future.

REFERENCES

1. Hodson D., (1993), Re-thinking old ways: towards a more critical approach to practical work in school science, *Studies in Science Education*, **22**, 85-142.
2. Hofstein, A., 2004. The laboratory in chemistry education: Thirty years of experience with developments, implementation and evaluation, *Chemistry Education Research and Practice*, 5, 247-264.
3. Hofstein, A. and Lunetta, V.N., 1982. The role of the laboratory in science teaching : Neglected aspects of research, *Review of Educational Research*, 52, 201-217.
4. Hofstein, A. and Lunetta, V.N., 2004. The laboratory in science education : Foundation for the 21st century, *Science Education*, 88, 28-54
5. Jrajick, J., Mamlok, R. and Hug, B 2001. Modern Content and Enterprise of Science: Science education in the 20th century
6. Lazarowitz, R., and Tamir, P., 1994. Research on using laboratory instructions in science in Gabel D L (ed.). *Hand book of research in science teaching and learning*, (pp. 94-130), New-York Macmillan.
7. Lunetta, V.N., Hofstein, A. and Clough, M., 2007. Learning and Teaching in the School Science Laboratory : An analysis of research, theory, and practice, In.N., Leaderman. and S. Abel (eds,). Handbook of research on science education. (pp. 393-441), Mahawah, NJ : Lawrence Eralbaum.
8. Matiru, B., Mwangi, A. and Schelette, R. (eds) 1995. Teach your best : A Hand Book for University lecturer. Germany, University of Kassel
9. Boud, D., Dunn, J. and Hegarty-Hazel, E., 1989. Teaching in the Laboratories. Philadelphia, Open University press.
10. Tamir, P., 1991. Practical Work in School Science: An analysis of current practice. In Woolnough, B.E., (ed.). Practical science Milton Keyness, Open University press.
11. National Research Council, 1996. *National education standards*, National Academy Press: Washington, D.C.
12. National Research Council, 2000. *Inquiry and the national science education standards*, National Academy Press: Washington, D.C.
13. American Association for the Advancement of Science, 1990, *project 2061, Science for all Americans*, Washington, D.c.
14. Hofstein, A. and Lunetta, V.N., 2004. The laboratory in science education : Foundation for the 21st century, *Science Education*, 88, 28-54
15. Klopfer L.E., 1990. Learning Scientific Inquiry in the Students' Laboratory. In Hegarty-hazel E (ed.). The student laboratory and the science curriculum. London, Croom Helm.
16. Morrell J.B., (1969), Practical chemistry at the University of Edinburgh, 1799-1843, *AMBIX*, **26**, 66-80.
17. Morrell J.B., (1972), Practical chemistry at the University of Edinburgh, 1799-1843, *AMBIX*, **26**, 66-80.
18. Gott, R. and Mashiter, J., 1991. Practical Work in Science. A Task-Base approach in Woolnough, B.E., (ed.) practical science, Milton Keyness, Open University press.
19. Woolnough, B, and Allosp, T., 1985. Practical Work in Science, Cambridge, Cambridge University Press.
20. Duckett S.B., Garratt J, and Lowe N.D., (1999), what do chemistry graduates think? *UniversityChemistry Education,* **3**, 1-7.

21. Statistics of Chemistry Education, published by the Royal Society of Chemistry online (last accessed 4/2/07) http://www.rsc.org/Education/Statistics/index.asp
22. Hunter C., Wardell S. and Wilkins H., (2000), Introducing first-year students to some skills of investigation in laboratory work, *University Chemistry Education*, **4**, 12-15.
23. Johnstone A.H. and Letton K.M., (1988), Is practical work practicable? *Journal of College Science Teaching*, **18**, 190-92.
24. Herron, M.D., 1971. The nature of scientific inquiry. *School Review*,79, 171- 212.
25. Raghubir, K.P., 1979. The laboratory investigative approach to science. Laboratory Experience and Student Learning.
26. Johnstone A.H. and Letton K.M., (1989), Why do practical work? A research point of view, *Kemia-Kemi*, (2), 146-50.
27. Best, K. and Kahn, B., 1999. Ethical guide lines in participating humans and treatment of persons in research. From (www.niches.nih.gov/research/resources/bioethicswhatis.cfm-41k-) 1999 review list pdf.
28. Anderson, L.W., 1990. Fundamental of Educational Research. London: The Flamer Pres.Alsamawat F., (2007), Private communication. This work is being developed for her thesis, to besubmitted for PhD, University of Glasgow, Glasgow.
29. Babbie, E., 1990. The Practice of Social Research (7th edition). Belmont (California): Wadsworth publishing company.
30. Wellington, J,J., 1996. Methods and Issues in Educational Research. London: Impact Graphics.
31. Merriam, S. B., 1988. Case study Research in Education. A Qualitative Approach. San Fransisco: Jossey Bass Publisher.
32. Yin, R.K., 2003. Case Study Research: design and Methods (3rd ed) London: Sage publication
33. Bogdan, R.C. and Biklen, S.K 1992. Qualitative Research for Education an Introduction to Theory and Methods Boston. Allyn and Bacon.
34. Babbie, E., 1968. The Practice of Social Research. Wadsworth: Thomson Learning Inc.
35. Holsity, L.R., 1969. Content Analysis for the Social Sciences and Humanities. Reading: Mass
36. Woolnough, B.E., (ed.), 1991. Practical Science. Milton Keynes, Open University Press.
37. Boud D., Dunn J. and Hegarty-Hazel E., (1986), *Teaching in laboratories*, Milton Keynes, Milton Keynes Open University Press.
38. Hegarty – Hazel, E. (ed.), 1990. The Student Laboratory and the Science Curriculum. London, Croom Helm.
39. Johnstone A.H., Watt A. and Zaman T.U., (1998), The students' attitude and cognition change to a physics laboratory, *Physics Education*, **33**, 22-29.
40. Johnstone A.H. and Letton K.M., (1990), Investigation undergraduate laboratory work, *Education in Chemistry*, **27**, 9-11

APPENDICES

Appendix I: Questionnaire to be filled by first year chemistry students

Dear students,

This questioner gives you an opportunity to indicate your practical experience and reaction to the course practical organic chemistry I. students' opinion is a valuable guide in the course planning and in evaluating the way it has been taught and the way the laboratory activities are carried out, so I kindly request you to respond to all the questions genuinely.

I appreciate your help in advance.

Please write only your sex in the space provided ________________________

Direction I; the following are statements about what you did in your practical organic chemistry I laboratory session, you are kindly requested to rate each item on the scale shown to indicate your level of agreement. Please indicate your response by putting a tick mark in one of the boxes against each statement.

SA -Strongly agree, A -Agree, UD -Undecided, DA -Disagree and SD –Strongly disagree.

No.	**Item**	**SA**	**A**	**UD**	**DA**	**SD**
1	The opportunity given to plan my own experiment is very satisfying					
2	Clear instructions are given about the experiment before doing the practical activities					
3	Standard experiments, written up correctly, give confidence to continue with chemistry					
4	Organic Chemistry laboratory should be about learning to do science through scientific investigations					
5	It is always easy for me to see the point and aim of what I am doing and the importance of every laboratory activities					
6	I feel most confident when the chemistry lessons were well structured and student directed					
7	I appreciated the opportunity if the teacher lets me plan my own activity.					

Direction II; the following are lists of aims for laboratory activities in science education; you are kindly requested to rank this list of aims from the most important to the least important.

NO.	**Item**	**Rank**
1	To improve mastery of the subject matter	
2	To develop scientific reasoning	
3	To demonstrate materials taught in lecture	
4	To build up practical skills	
5	To design experiments to test hypothesis	
6	To interpret experimental data	
7	To promote interest in chemistry	
8	To formulate hypothesis	
9	To work out problems	
10	To introduce equipments and develop observational skills	

Appendix II: Questionnaire to be filled by laboratory instructors
Dear instructor,
This questioner gives you an opportunity to reply to what should be the objectives of laboratory or practical chemistry courses in university chemistry. Your opinion is a valuable guide in the course planning and in evaluating the way the laboratory activities are carried out, so I kindly request you to respond indisputably.

I appreciate your help in advance.

Please write only your sex in the space provided ________________________

Direction; the following are lists of aims for laboratory activities in science education; you are kindly requested to rank this list of aims from the most important to the least important.

NO.	Item	Rank
1	To improve mastery of the subject matter	
2	To develop scientific reasoning	
3	To demonstrate materials taught in lecture	
4	To build up practical skills	
5	To design experiments to test hypothesis	
6	To interpret experimental data	
7	To promote interest in chemistry and in learning science	
8	To formulate hypothesis	
9	To work out problems	
10	To introduce equipments and develop observational skills	

Appendix III: Laboratory Activities Observation Checklist
The main purpose of this observation checklist is to assess and evaluate students' activity in practical organic chemistry I laboratory session

NO.	Checklist for performed activities	Yes	No
1	Pre-laboratory exercises		
2	Set up the instruments that they are going to use		
3	Plan to use suitable equipments or sources of evidences		
4	Decide on a suitable number and range of readings or observations		
5	Use information from preliminary work to guide their plan		
6	Record their result clearly and accurately		
7	Explain what their result shows		
8	Draw a conclusion that fits their results and explain it using their scientific knowledge		

Appendix IV: A typical level 0, 1 and 2 respectively inquiry exercises in the manual
1. SURVEY OF SOME FUNCTIONAL GROUPS
1.1 Tests for Phenols.
1. Place 20 drops of 10 % aqueous solution of phenol in a test tube
2. Add to this 3 drops of 2 % of neutral ferric chloride solution.

The development of a violet color is characteristic of the phenol functional group.

2. FRACTIONAL DISTILLATION

Mixtures of volatile liquids can be separated in to their component parts by a technique known as fractional distillation. In this process volatile liquids, which boil with in 25 ^{0}c of each other are separated in to components which are called fractions.

1. pour the provided 50 ml of ethanol-water mixture in to the distilling flak
2. place the distilling flak over a water bath, introduce two or three boiling chips, get the set up checked by the instructor and then start the fractional distillation
3. Collect the distillate directly in to a measuring cylinder and record the temperature after every 2 ml. when the temperature begins to fall down remove the water bath and heat the flask with a gentle flame
4. Change the receiver and record the temperature after every 2 ml as before. Collect 10 more ml of distillate
5. Hand over the two distillates separately to your instructor and report the volume of each distillate and the percent composition of the starting ethanol water mixture. Tabulate your data and plot a graph showing the relation ship of temperature (y-axis) and volume (x-axis).

3. QUALITATIVE ORGANIC ANALYSIS

In this experiment each student in the laboratory will be given an unknown compound designated by a code. The unknown is selected from the compounds listed below.

Lists of compounds from which unknowns for this experiment are selected

Neutral compounds: Acetanilide, Maleic anhydride Acids and Phenols: Maleic acid, Stearic acid, Salicylic acid and Acetylsalicylic acid Amines: P-toluidine, anillinehydrochloride. Carbohydrates: D(+)Glucose, sucrose, starch

1) Conduct solubility tests and class a reaction as described in the previous experiment and deduce what your unknown is based on your overall observations.

Source: Ermias Dagne (1989: 19, 11, 41). Experiments in Organic Chemistry, 2nd edition

Appendix V: Discrete activities in the manual

Experiment number	Experiment title	Activities included in the experiment
1	Recrystallization	- purification of contaminated sample of organic compounds by recrystallization
2	Determination of melting points and simple distillation	- determination of the melting point of a substance purified by recrystallization - purification of a contaminated liquid by simple distillation
3	Fractional distillation	- fractional distillation of liquid mixtures
4	Steam distillation	- steam distillation of typical organic compounds like aniline, toluene or bromobenzene - demonstration of the steam distillation of an essential oil containing plant

5	Survey of some functional group	- solubility of alkanes in water - solubility of alkanes in ethanol - solubility of alkanes in petroleum ether - solubility of alkanes in concentrated H_2SO_4 - solubility of kerosene in water - solubility of kerosene in ethanol - solubility of kerosene petroleum ether - solubility of kerosene in concentrated H_2SO_4 - reaction of alkanes with bromine in the dark - reaction of alkanes with bromine in presence of sun light - the effect of oxidizing agents on hydrocarbons - solubility of alkenes in concentrated H_2SO_4 - solubility of alkenes in water - solubility of alkenes in ethyl alcohol - reaction of alkenes with bromine - reaction of alkenes with aqueous permanganate solution - generation of acetylene - bromination test for acetylene - Baeyer's test for acetylene - Test for unsaturation - Nitration of benzene or toluene - Test for ketones - Test for phenols
6	Stereochemistry	
7	Preparation of aspirin	- preparation of aspirin - solubility of aspirin in water - solubility of aspirin in ethanol - solubility of aspirin in $NaHCO_3$ - solubility of salicylic acid in water - solubility of salicylic acid in ethanol - solubility of salicylic acid in $NaHCO_3$ - test for phenolic hydroxyl group using aspirin - test for phenolic hydroxyl group using salicylic acid - determination of melting point of aspirin
8	Preparation of soap	- preparation of soap - test of the alkalinity of the prepared soap - test of the alkalinity of ordinary soap - test of alkalinity of Omo - reaction of the prepared soap with $CaCl_2$, $FeCl_3$ and HCl - reaction of the ordinary soap with $CaCl_2$, $FeCl_3$ and HCl - reaction of the Omo soap with $CaCl_2$, $FeCl_3$ and HCl
9	Chromatography	- paper chromatography - thin layer chromatography - column chromatography
10	Proteins and Carbohydrates	- isolation of casein - solubility of casein in concentrated HCL - solubility of casein in NaOH - xanthoproteic test - nitrous acid – casein reaction - xanthoproteic test of albumin - test for sulfur in albumin - the Biuret test of albumin - precipitation of albumin with salts of heavy metals - solubility of glucose in water - solubility of in ethanol - solubility of sucrose in water

		- solubility of sucrose in ethanol - solubility of starch in water - solubility of starch in ethanol - preparation of 5 % aqueous solution of glucose - preparation of 5 % aqueous solution of sucrose - the Molisch test - Fehling's test with glucose solution - Fehling's test with sucrose solution - Osazone formation
11	Qualitative organic analysis part I	- preliminary examination of a given compound - solubility classification of the given compound - test for unsaturation using $KMnO_4$ - test for unsaturation using Br_2 - Fehling's test of carbohydrate - Benedict's test of carbohydrate - Litmus paper test for carboxylic acid - $NaHCO_3$ test for carboxylic acid - $FeCl_3$ test for phenols - Ninhydrin test for Amino acids - $CuSO_4$ test for amino acids - 2, 4- Dinitrophenyl hydrazine test for aldehydes and ketones - Test for primary aromatic amine
12	Qualitative organic analysis part II	- Identifying unknown organic compounds

Source: Ermias Dagne (1989) experiments in Organic Chemistry 2nd edition

ACKNOWLEDGEMENTS

First and foremost, I would like to express my deepest gratitude to the almighty lord, Jesus Christ for His infinitive help throughout all my life. My special appreciation goes to Haramaya University, Faculty of Education, DIF project for offering financial support to conduct this research. I would also like to take this opportunity to thank Dr. Temechegn Engida and Mr. Mulugeta Assefa (Assistant Professor) for their valuable advices.

USING SYSTEMIC PROBLEM SOLVING (SPS) TO ASSESS STUDENT ACHIEVEMENT IN CHEMISTRY[ϒ]

*Ameen F. M. Fahmy and **J. J. Lagowski
* Faculty of Science, Department of Chemistry, Ain Shams University, Egypt
E-mail: fahmy@online.com.eg
** Department of Chemistry and Biochemistry, the University of Texas at Austin, USA
E-mail: jjl@mail.cm.utexas.edu

ABSTRACT

This paper focuses on the uses of systemic problem solving in chemistry at the tertiary level. Traditional problem solving (**TPS**) is a useful tool to help teachers examine recall of information, comprehension, and application. However, systemic problem solving **(SPS)** can challenge students and probe higher cognitive skills like analysis, synthesis, and evaluation. Also**,** systemic problem solving **(SPS)** helps students to connect chemistry concepts, and facts and covers a wide range of intended learning outcomes (**ILO,s)**. As an example, the type of chemical bonding in compounds, molecular structure, and their relations to stereochemistry, reflected on certain physical properties (e.g., dipole moment, IR, UV, NMR, M**S,…**), as well as chemical properties. So, by using **SPS** we assess the student achievement in three systemic levels of learning chemistry: the macro (properties, and reactions), the sub-micro (atoms, molecules, and molecular structure), and the representational (symbols, formulas, equations). In this issue we illustrate two examples on the uses of systemics in chemistry problems and their solutions. *[AJCE, 2(3), July 2012]*

[ϒ] Presented in the 42nd IUPAC Congress, Chemistry Solutions; Glasgow, August 2- 7 (2009).

INTRODUCTION

It was stated (1-2) that much of chemistry contents, at the secondary and tertiary levels, taught and assessed in terms of facts and concepts without emphasizing conceptual understanding In the traditional linear way of teaching students are taught and assessed in many pieces of knowledge without any emphasis on connecting this knowledge into a functional framework.

For example, chemistry program in tertiary level might group learning into a separate course topics, such as stoichiometry, the periodic table, chemical bonding, molecular structure, stereochemistry, chemical equilibrium, oxidation-reduction reactions, thermo chemistry, thermodynamics, reaction mechanisms, and spectroscopic analysis. The student learns these topics in a separate way without any connection between them.

In response to these concerns, many reform efforts have called for a shift of chemistry education from memorization of facts and concepts to a deeper understanding of the subject matter. This focuses on learning for understanding and is grounded in the theory of conceptual change to explain how learners achieve conceptual understanding by connecting concepts, experience, and strategies (3).

In the last fifteen years we (4-8) designed, implemented, and evaluated the systemic approach to teaching and learning chemistry (SATLC) model that organizes the overarching concepts of chemistry into a framework from level of understanding to analysis and synthesis. Also we have designed a new type of objective tests in chemistry based on systemics (9-10). We have also proposed systemic assessment (SA) of learners to produce a more efficient evaluation of the systemic- oriented objectives in the SATL techniques and as an effective tool for assessing students' meaningful understanding of chemistry topics at the secondary and tertiary levels (11).

This paper focuses on the use of the systemic approach to teach problem solving in chemistry at the tertiary level. Traditional, problem solving (TPS) as a process has been presented to students by the teacher doing problems, in effect showing them how to do certain types of "hard" problems, and then assigning similar problems for students to practice. It is usually assumed that students will reach conceptual understanding through sufficient practice of problem solving (12). By repetitive practice on this kind of approach to problem solving many students may develop speed and accuracy for routine problems, but they fail to develop their ability to reflect on what they have done or how to adapt this to solving new different problems. Over and above, the students solve these routine problems as snapshots without any framework connecting their ideas or even solutions to the context of the problem. This approach stresses linearity in problem solving, and linear thinking; as such, it relies on memorization.

In contrast, systemic problem solving (SPS) helps students to connect concepts, facts, for example, the type of chemical bonding in compounds, and its relationship to stereochemistry with certain physical properties (e.g., dipole moment, IR, UV, NMR, MS,…), as well as chemical properties. SPS can assess student achievements at higher cognitive skills like analysis, synthesis and evaluation.

Systemic problems were designed to assess chemistry students from different class levels of faculty of science. So we can design the systemic problems into different grade levels (grades 1, 2, 3, and 4) according to the tested items.

- *In grade -1*: The students are able to identify the organic compounds from their molecular formulas and chemical behavior, as the students progress to more sophisticated levels of understanding. They can apply their understanding of bonding to monitor the changes in hybridization of the carbon atoms, and changes in physical properties like dipole moment when they move from one type of compounds to another type in the systemic.

- *In grade -2:* The students are able to do the previous items beside monitor the changes in the stereo isomerism of the compounds under consideration.
- *In grade -3*: the students are able to do the previous items beside the use of stereo chemistry to explain the mechanisms of all the reaction steps.
- *In grade-4:* At this point the students are able to do the previous items and relate them with spectroscopic data of all compounds under consideration.

WHY SYSTEMIC PROBLEM SOLVING (SPS)?

Systemic problem solving (SPS) has the following advantages:

i. it measures the students' ability to correlate between concepts;

ii. it measures the student skills to monitor the changes in physical and chemical properties in a series of chemical reactions;

iii. it measures the cognitive structure from the quantitative through the qualitative domains;

iv. it assesses students' higher-order thinking skills where they are required to analyze, synthesize, and evaluate;

v. it assesses students in a wide range of concepts in the course units; or in the different courses unites;

vi. it measures the systemic intended learning outcomes (SILOs) beside linear intended learning outcomes (LILOs);

vii. it develops the student ability to think systemically, critically, and creatively, and to solve problems systemically.

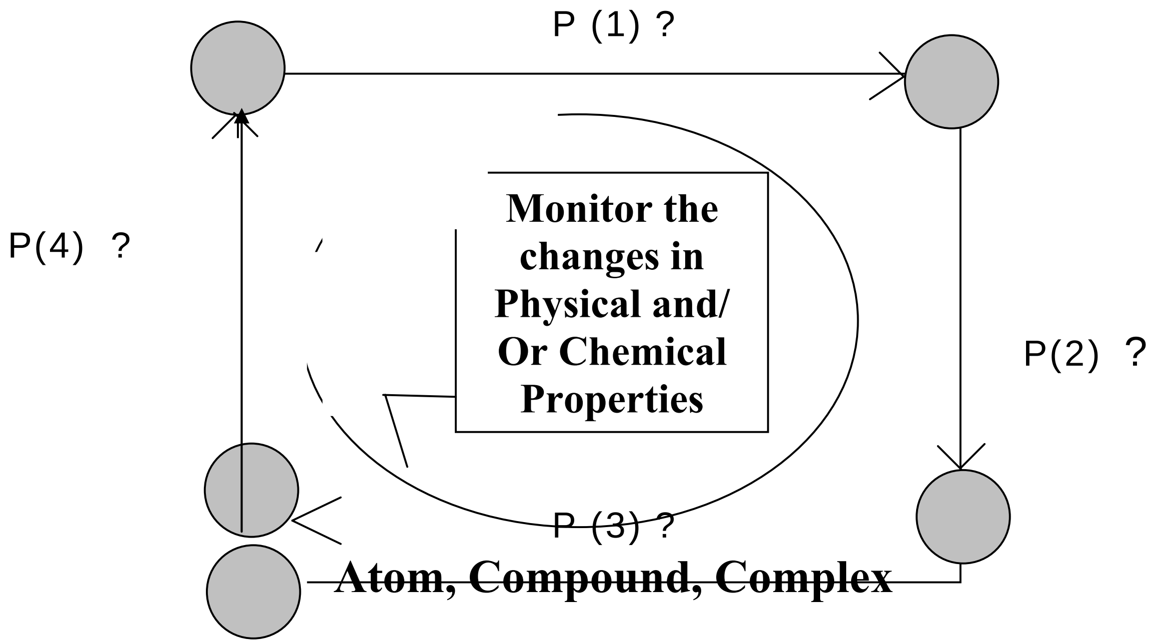
In terms of objectives of the SPS, we expect from our chemistry students after training on SPS to i) produce systemic solutions for any complex chemical problem, ii) enrich their problem solving ability, iii) monitor the changes in physical and chemical properties of different types of compounds formed in a series of reactions, iv) make maximum connections between, compounds and their properties, v) achieve three systemic levels of learning chemistry (13): the macro (properties and reactions), the sub-micro (atoms, molecules and molecular structure), and the representational (symbols, formulas and equations).

REQUIRMENTS FOR BUILDING SYSTEMIC PROBLEMS

We start the problem by giving the students the molecular formulas of all compounds in the given series of reactions with reaction conditions, and then we ask the students to do the following;

1. Write the structural formulas and names of all compounds under consideration (sub-micro and *representational levels*).
2. Write the series of chemical reactions of compounds with reagents and reaction conditions (macro and *representational levels*).
3. Build a systemic diagram of the above chemical reactions (*representationa*l). The size of systemic will depend on the number of compounds including in the series of reactions.
4. Then monitor the following changes among the compounds presented in the systemic diagram:
    - The state of hybridization (*sub-micro level*)
    - The stereochemistry (*macro level*)
    - Some physical properties like dipole moment (*macro level*)
    - The spectroscopic data like IR, UV, HNMR, C13NMR, MS (*macro level*)

GENERAL PRESENTATTION OF SYSTEMIC PROBLEMS (SP)



Examples: The following examples are intended to illustrate how SPS in Chemistry have been and can be used to assess 4th grade students of Faculty of Science, Ain Shams University, Egypt.

<u>Systemic problem -1: (SP-1)</u>

Compound $\mathbf{C_4H_8}$ (**A**) exists in two geometrical isomers and reacts with dilute alkaline $KMnO_4$ to give $\mathbf{C_4H_{10}O_2}$ (**B**). Compound (B) reacts with PBr_3 to give vicinal dibromo compound $\mathbf{C_4H_8Br_2}$ (**C**). The dibromo derivative (C) reacts with alcohol KOH to give $\mathbf{C_4H_6}$ (D).

1) Write the names and draw the structural formulas of compounds (**A** $\longrightarrow$ **D**).
2) Draw the stereo isomers of compounds (**A** $\longrightarrow$ **C**).
3) What are the types of hybridizations in compounds (**A**), (**D**)?

4) Give the systemic clockwise chemical relations between compounds (**A**⟶ **D**) in a systemic diagram.

5) Monitor the changes of the following items in this systemic:

i) Functional groups.

ii) Reaction type for each step.

iii) Systemic change in hybridization of (C_2-C3) when we move from compound (**A to B-C-D**)

iv) Systemic change in stereoisomerism when we move from compound (**A to B-C- D**)

v) Systemic change in **IR** bands when we move from compound (**A to B-C- D**)

vi) Systemic change in **1H. N. M. R**. signals, when we move from compound (**A to B-C- D)**

Answer:

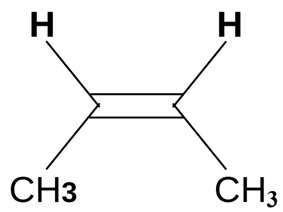
H H
| |
1) **Butene - 2**: CH_3 - C = C - CH3

2 , 3 –Dihydroxy butane: CH_3 – CH - CH - CH_3
| |
OH OH

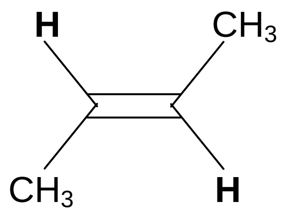
2, 3-Dibromobutane: CH_3 – CH - CH - CH_3
| |
Br Br

2 - Butyne: $CH_3 - C \equiv C - CH_3$

2)

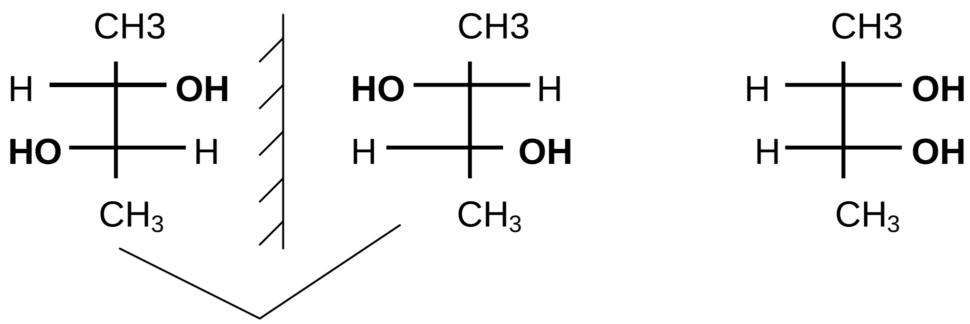


Z - Butene– 2

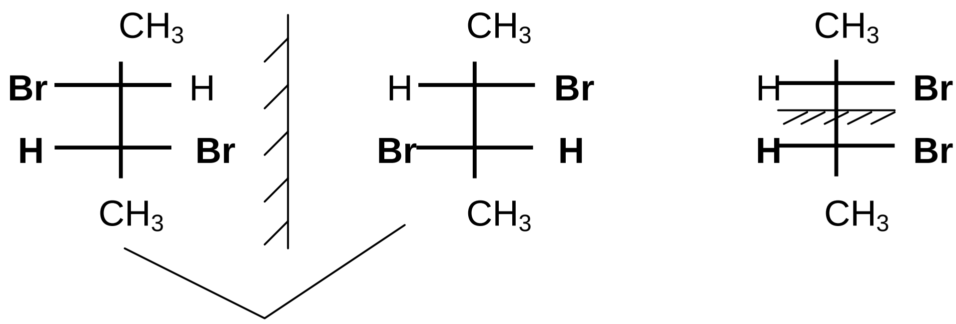


E - Butene- 2

 ISSN 2227-5835



(DL) (meso)



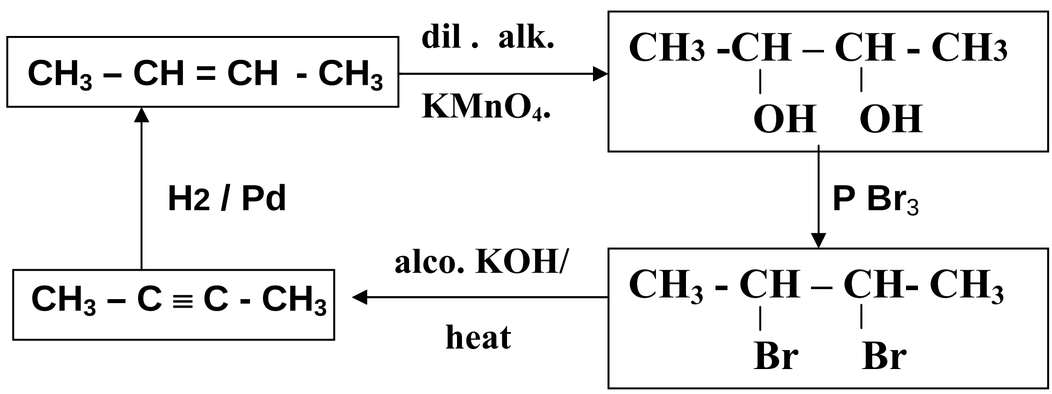
(DL) (meso)

3) $CH_3 - \overset{H}{\overset{|}{C}} = \overset{H}{\overset{|}{C}} - CH_3$ **(A)** $CH_3 - C \equiv C - CH_3$ **(D)**

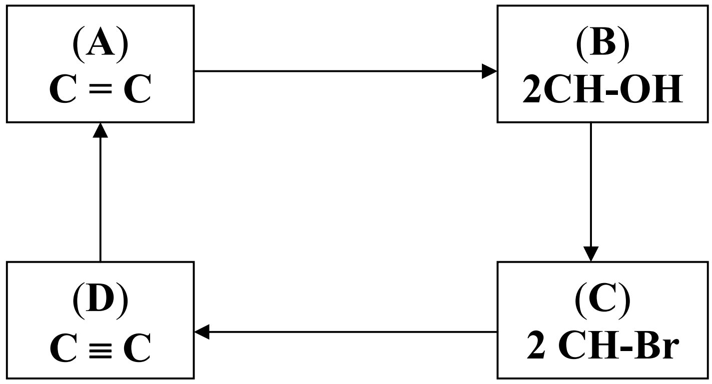
2 3 2 3

(Sp2) **(Sp3)**

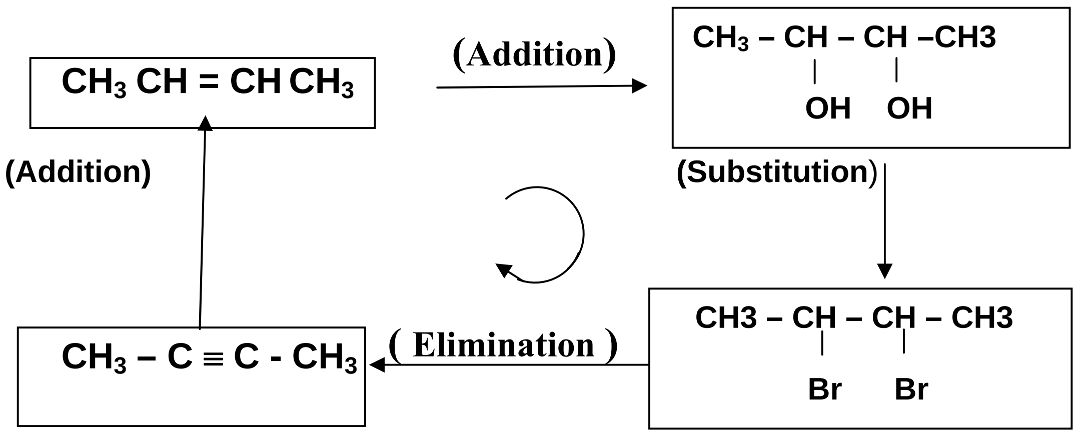
4)



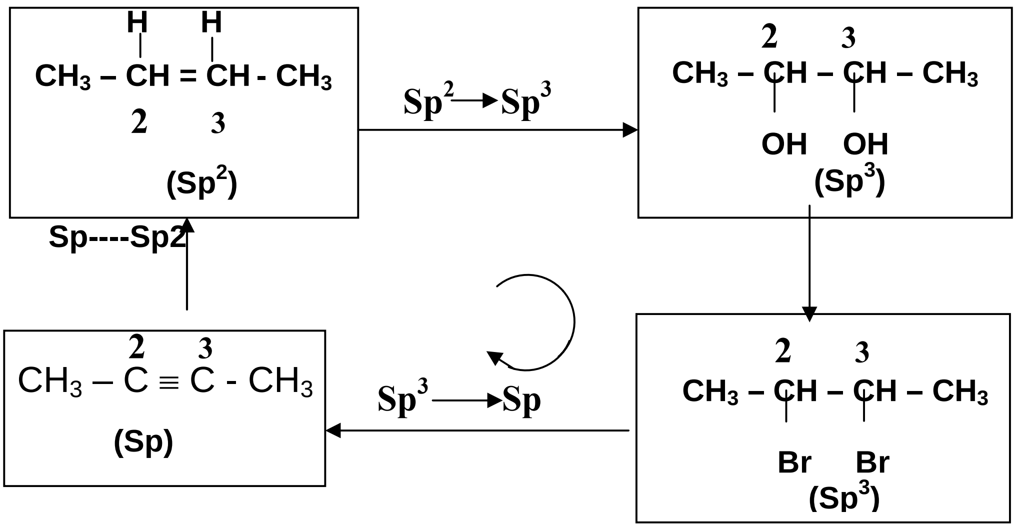
5) –i Monitory of the Changes in the Functional Groups:



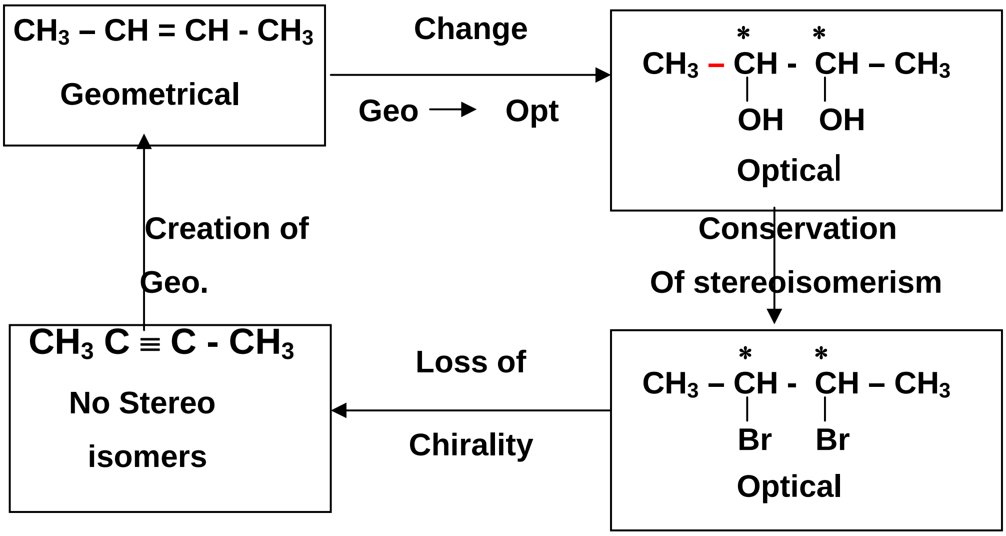
(ii) Monitory of the Change in the reactions type:



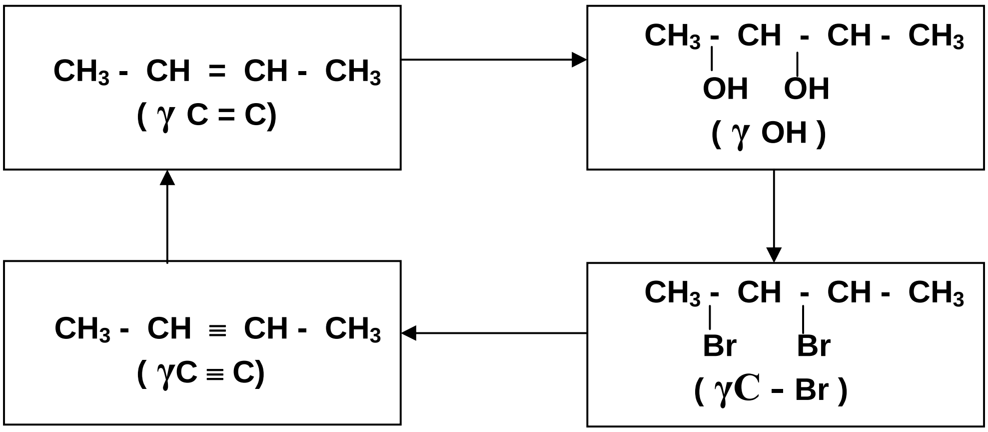
(iii) Monitory of the Systemic Change in hybridization of (C2- C3)



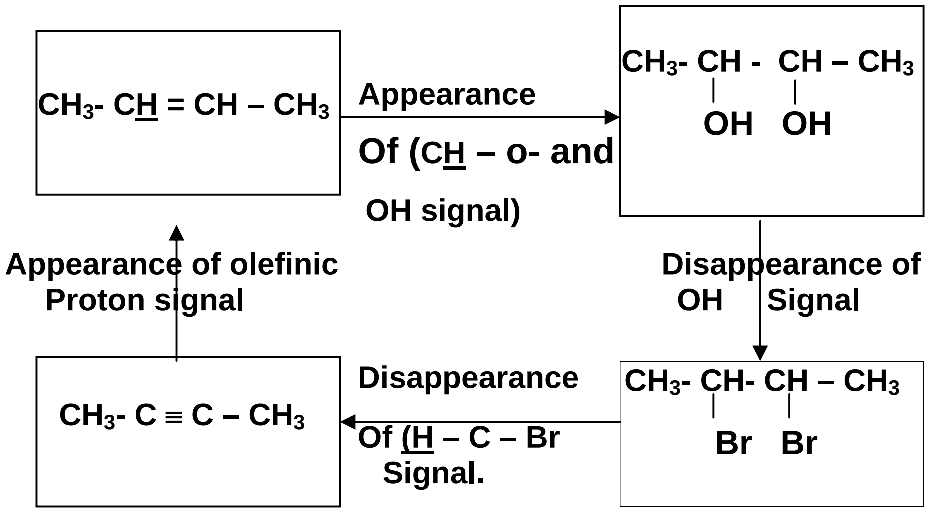
iv) Monitory of the Systemic Change in the stereoisomerism:



(V) Monitory of the Systemic Change in the IR bands:



(vi) Monitory of the Systemic Change in the 1HNMR:



Systemic problem -2: (SP-2)

Aromatic compound $\mathbf{C_7H_8}$ (**A**) reacts with Cr_2O_3 / acetic acid to give $\mathbf{C_7H_6O}$ (**B**) which reacts with $KMnO_4$ / Conc. H_2SO_4 to give $\mathbf{C_7H_6O_2}$ (**C**). By heating (**C**) with soda lime under dry conditions gives liquid (**E**).

(1) Write the names and draw the structural formulas of Compounds (**A**⟶**D**).

(2) Give the systemic clockwise chemical relations between compounds (**A** ⟶ **D**) in a systemic diagram.

(3) Monitor the changes of the following items in the systemics.

a. Functional groups

b. Type of reaction in each step.

c. I. R spectra.

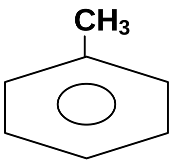
d. 1H. N. M. R. Spectra.

e. Molecular ion peaks in the Mass spectra.

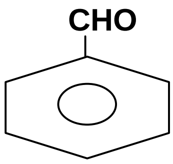
f. Ease of reactions with Electrophiles.

Answer:

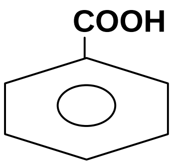
1)



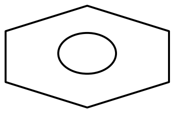
Toluene (A)



Benzaldehyde (B)

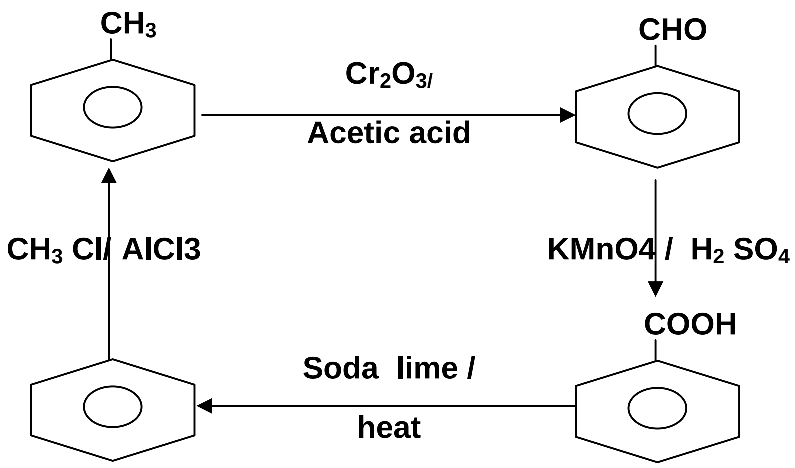


Benzoic acid (C)

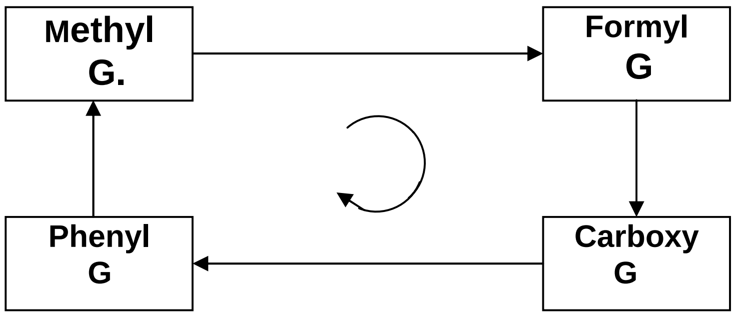


Benzene (D)

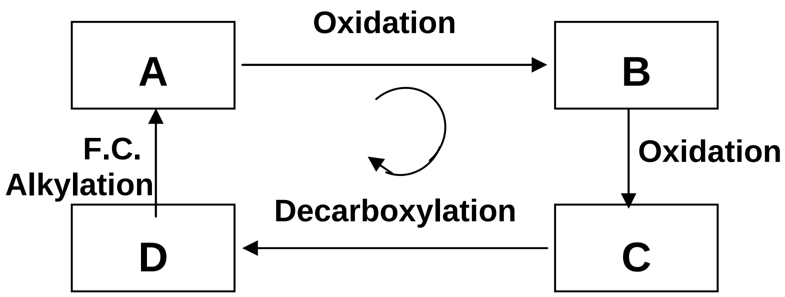
2)



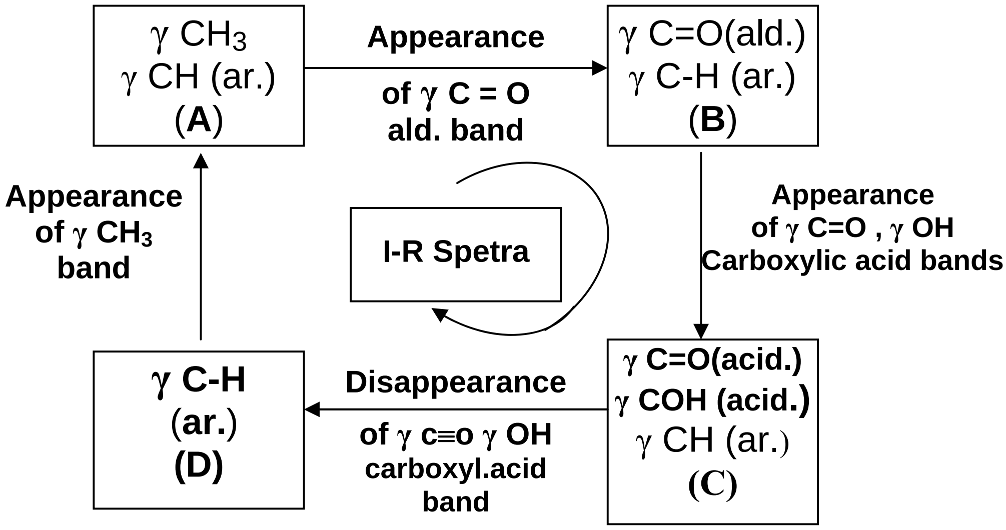
3. i.



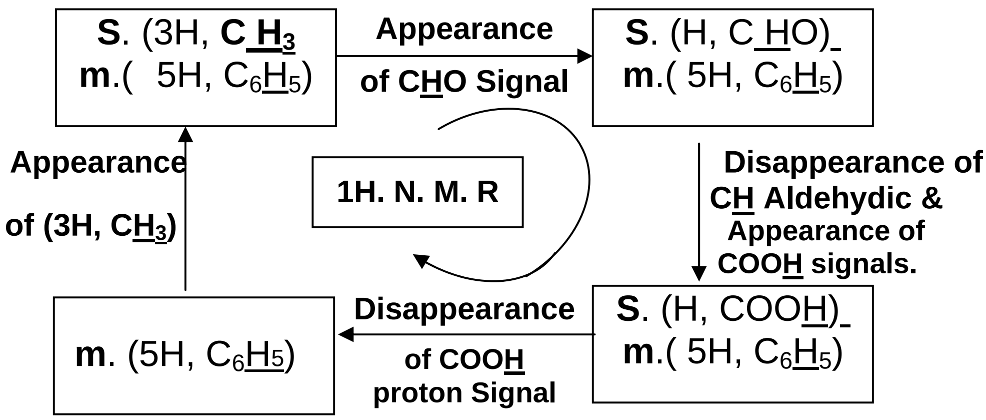
3. ii.



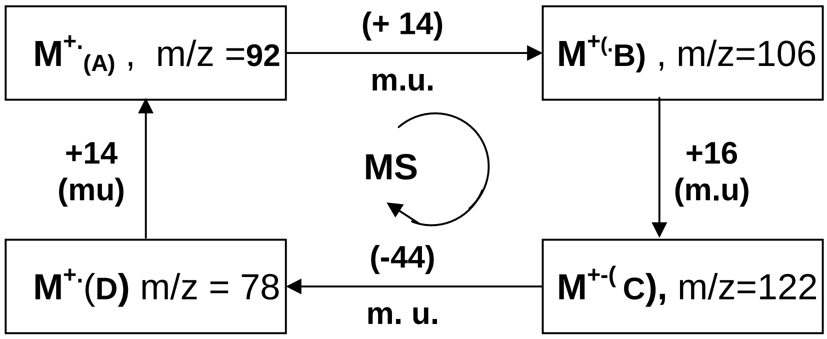
3. iii Monitory of the Systemic Change in the IR- Spectra.



3. iv. Monitory of the Systemic Change in the 1HNMR:

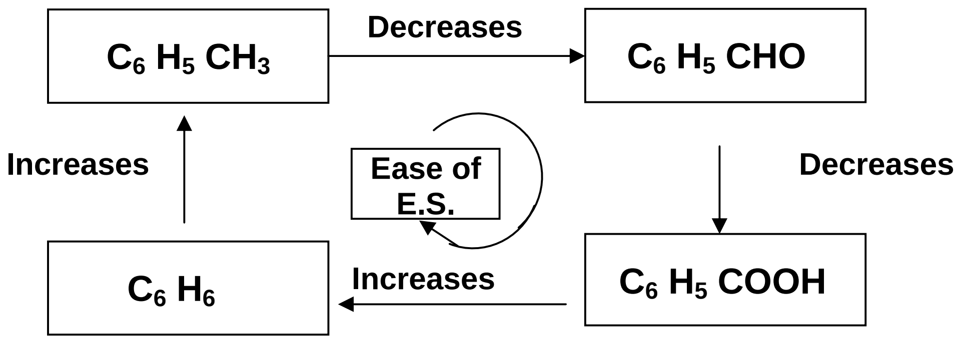


3. V. Monitory of the Systemic Change in Mass Spectra:



(mu = Mass Unites)

3.vi. Monitory of the Systemic Change in Electrophilic substitution.



By using SPS strategy students reached to higher levels of competence as the new concepts are linked to the existing concepts in their cognitive structure. This is in contrast to a traditional linear problem solving which gives the students more fragmented view of the discipline in which students often fail to integrate their knowledge.

REFERENCES

1. Hesse, J. & Anderson, C.W. (1992). Students Conceptions of Chemical Change. *Journal of Research in Science Teaching* 29 (3) 277-299.
2. Phelps, A. (1996). Teaching to Enhance Problem Solving.: It's more than just numbers. *Journal of Chemical Education* 73(4) 301-304.
3. Smith, J.P., diSessa, A. & Roschelle, J. (1993). Misconceptions Reconceived: A Constructivist Analysis of Knowledge in Transition. *The Journal of the Learning Sciences* 3(2) 115-163.
4. Fahmy, A. F. M. and Lagowski, J. J. (1999).The Use of Systemic Approach in Teaching and Learning for 21st Century, J. J. Pure Appl. Chem, 71,
5. Fahmy,A.F.M ; Lagowski J (2003). Systemic Reform in Chemical Education an International Perspective, J. Chem. Educ. 80, 1078–1083.
6. Fahmy; A.F.M. J. Lagowski, J. (2011). The systemic approach to teaching and learning (SATL) A 10-year review,AJCE.1 (1), 29-47.
7. Lagowsk, J; Fahmy, A.F.M. (2011). The systemic approach to teaching and Learning (SATL): operational steps for building teaching units,AJCE.1 (1), 62-80.
8. Fahmy, A.F.M.; Said, A, (2011),The systemic approach to teaching and learning water chemistry, AJCE.1 (2), 62-80.
9. Fahmy, A. F. M.; Lagowski, J. J. (2004). Using SATL Techniques to Assess Student achievement. In Proceedings, 18th International Conference on Chemical Education, August, 3-8, Istanbul, Turkey].
10. Fahmy,A.F.M, Lagowski,J.J. (2006),Systemic Multiple Choice Questions (SMCQs) in Chemistry [19th ICCE, Seoul, South Korea, August 12-17].
11. Fahmy, A. F. M.; Lagowski, J. J.(2012). Systemic assessment as a new tool for assessing students learning in chemistry using SATL Methods; Systemic True False [STFQs] and Systemic Sequencing [SSQs] Question Types, AJCE.2(2) 57-78.
12. Hollingworth, R,(2001) Chemical Education Journal (CEJ) 5(.2), http://www.juen.ac.jp/scien/cssj/cejrnlE.html
13. Johnstone A.H. (2000). Teaching of Chemistry – logical or psychological? CERAPIE 1, 9.
14. Barke ,H.D.(2012). Two ideas in the redox reactions, AJCE.2(2), 32-50.

THE EXTENT TO WHICH THE CHEMISTRY TEXTBOOK OF GRADE 11 IS APPROPRIATE FOR LEARNER-CENTERED APPROACH

Tolessa Mergo
Akaki Adventist School, Addis Ababa, Ethiopia
Email: toessamergo@yahoo.com

ABSTRACT

The purpose of this study was to identify the extent to which the chemistry textbook of grade 11 in Ethiopian schools is appropriate for learner-centered approach. The content of the new chemistry textbook for grade 11 was analyzed vis-à-vis the suggested evidence of learner-centered techniques. The analysis covered the components of the textbook such as objectives, texts, activities, questions, and figures and diagrams. The results of content analysis revealed that only the activities given in the text encourage student's involvement in the teaching learning process. *[AJCE, 2(3), July 2012]*

INTRODUCTION

Curriculum is a crucial component of any educational process. Education is unthinkable without curriculum. Curriculum materials are central elements or the main means to achieve the purposes of education. Having appropriate curricular materials (teachers' guide, students' textbook, etc) helps to promote student-centered learning and ensure quality education. Within active learning system curricular materials (syllabus, teacher's guide, and textbooks) are very significant to implement the method. In designing curricular materials, it becomes very important to recognize the inevitability of mixed groups in terms of proficiency and also in terms of preferred learning styles, so that they can be used in variety of ways (1). If students should be critical thinkers and problem solvers, textbooks should be designed in the way they ensure ample opportunities for learners to question, apply and consolidate new knowledge. Hence, there will be opportunities to experience and understand science concepts and processes through hands-on, minds-on and authentic real-life related problem solving activities.

In most cases the bodies of textbooks are texts, activities, exercises and illustrations. When the writer (author) designs the textbook, he/she thus pays attention to the components of learning such as texts, activities, questions and figures which invite active leaning (2) and are described below.

Texts

Romey (3) developed the students involvement index of texts presentation for grades 7-10 science textbooks. According to Romey; facts, conclusions, definitions, and questions answered immediately by the text are taken as "non involvement". Whereas, questions requiring the students to analyze data, statement requiring the students to formulate conclusions, directions requiring them to analyze and perform activities or solve problems and questions designed to arouse interest are taken as “involvement”. The choice of the Romey index of involvement is somewhat arbitrary. However, since the presentation of knowledge in the text influence the implementation of science teaching, it seems appropriate for evaluating the presentation of the texts of science textbooks by using that involvement index (4). Accordingly, the researcher of this study analyzed the knowledge presented in the texts of grade 11 chemistry textbook by adapting the involvement index developed by Romey (3) and latter adapted by Fletcher (4).

Activities

Textbooks can have several purposeful activities that require the learners to work together and gives instructions concerning what to do and how to do it (5). Most learning takes place when we actually try to do something. Learning does not happen efficiently when we merely read about something or listen to someone talk about it. The actual measure of a good learning package is what the students do as they work through it.

Questions

Cotton cited in Solomon (6) defines a question as “….any sentence which has an interrogative form or function. In classroom settings, questions are defined as instructional cues or stimuli that convey to students the content elements to be learned and directions for what they are to do and how they are to do it.” This definition makes it clear that questions are not limited to the grammatical form that ends with question mark only. A question is rather understood as any utterance or cue that elicits responses or some kind of human interaction.

There are certain considerations for good questions. For instance, they should be formulated in clear language and one has to avoid questions permitting “yes or no” answers or one word answers. Good questioning takes into account the pupils' background or experience and their ability to form judgment. It will not be confined to memory or recall questions. Questions can also be classified on the basis of their level of cognitive difficulty such as lower order (lower cognitive) and higher order (higher cognitive) questions (6, 7).

Figures and Diagrams

The term figures or/and diagrams means any drawing that can serve as the condensed visual form of a lesson. Effective methods and means of teaching include figures, diagrams, pictures, graphs, photographs, illustrations, drawings, etc as the types of visual teaching aids (8). Observation may also be recorded by drawing (9). These must not be ideas, copies of drawing but must be made from actual things. Figures/diagrams should not be put only for illustrative purposes. They should also be used for doing activities and exploring something.

The traditional curriculum at different times of our country's education was noted for reinforcing factual knowledge through academic content centered curriculum, teacher dominated classroom instruction and rote memorization oriented assessment. These situations fostered superficial learning which cannot change the social, economical, political and cultural aspects of the country and to the lives of each individual as desired. Cognizant of these facts, the Education and Training Policy of Ethiopia—TGE (10)—gives due emphasis for strengthening of the individuals' and society's problem-solving capacities at all levels. As stated in the (10) one of the objectives of education is to develop the physical and mental potential and problem solving capacity of individuals by expanding basic education for all. It is also argued that learner-centered approach prepares and enables learners to solve problems, makes them creative and user information from their environment and other sources to make a better life for themselves, the society and the country as a whole (10).

To make these assertions practical, the government of Ethiopia has recently developed textbooks that encourage the learner-centered method, including chemistry teaching textbook to high school students (11). This study has therefore been designed to give insight into identifying the extent to which the Chemistry textbook of grade 11 is appropriate for learner-centered approach

RSARCH METHODOLOGY AND PROCEDURES

Content analysis was used to identify the extent to which the grade 11 Chemistry textbook is appropriate for learner-centered approach. For this purpose, the content of the new Chemistry textbook for grade 11 was analyzed vis-à-vis the suggested evidence of learner-centered techniques. The analysis covered the components of the book such as objectives, texts, activities, questions, and figures and diagrams.

The objectives outlined in the textbook were analyzed using major categories of the Bloom's educational objectives. The Bloom's cognitive domain includes those objectives that emphasize intellectual outcomes such as knowledge, comprehension, application, analysis, synthesis and evaluation. The first three: knowledge, comprehension and application are categorized as lower level of learning outcomes in cognitive domain. The other three: analysis, synthesis and evaluation are categorized as higher level outcomes.

Texts include facts, conclusions, definitions, questions answered immediately by the text, questions requiring the students to analyze data, statements requiring the students to formulate conclusions and directions requiring them to analyze and perform activities or solve problems.

The students involvement index (SII) of the knowledge presented in the new Chemistry textbook is computed based on the developed procedure of Romey (3) as the ratio of active involvement (AI) to passive involvement (PI). Active involvement is measured by a) skills, b) unanswered in-text questions and c) real examples. Passive involvement, on the other hand, is measured by d) concepts (factual information), e) immediately answered in-text question and f) unreal examples (See Appendix I). Therefore, SII can be described as

$$AI/PI = \frac{a+b+c}{d+e+f}.$$

According to Romey (3), a value "0" for the ratio AI/PI represents no students involvement'; a value between "0" and "0.4" represents' below average, a value between "0.4" and "1.5" represent average and values above 1.5 represents best for students involvement in texts.

Figures and diagrams were analyzed by using two categories of students' involvement index (8). Accordingly, for this study, figures and diagrams used only for illustrative purposes were categorized under 'passive involvement' and figures and diagrams which require students to perform certain activity to answer questions and exploring something were categorized in 'active involvement (see Appendix I).

In order to analyze the activities suggested in the textbook, the inquiry level index for activities developed by Heron (12) was used. Inquiry level index has four levels depending on the tasks that students have to accomplish.

Level Zero: the question, the method, and the answer are all provided.

Level One: the question and the method are given; the student has to find the answer..

Level Two: the question is given; the student has to design a method and to find an answer.

Level Three: the student is presented with the phenomenon, she/he has to formulate a relevant question, design a method and find an answer to the question.

In analyzing the activities, the first level i.e., “level 0”, structured with given (closed) problem, procedure and solution, is categorized as ‘passive involvement’ and the three levels: ‘level 1’, ‘level 2’ and ‘level 3’, structured with one or more of problem, procedure or/and solution be opened to learners investigation, are categorized in ‘active involvement’(see Appendix I)

The following levels of questions were used in evaluating the order of thinking: literal, inferential and critical questions. In analyzing the questions the first level, literal, is categorized under ‘passive involvement of learners ’i.e., lower order thinking and the rest two levels: inferential and critical are categorized in ‘active involvement of learners’ i.e., higher order thinking questions (see Appendix I)

RESULTS AND DISCUSSIONS

Content Analysis of Grade 11 Chemistry Textbook

As mentioned above in this study content analysis of grade 11 textbook covers the objectives, texts, figures and diagrams, activities and questions given in the textbook. The results are therefore presented and discussed in the ensuing paragraphs.

Table 1 shows the distribution (%) of the objectives by categories of cognitive processes.

Table 1: Distribution (%) of Objectives by Categories of Cognitive Processes

Unit	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Total
1	11	2	4	4	1	0	22
2	18	20	5	2	2	0	47
3	20	30	10	9	1	0	70
4	11	15	9	0	0	0	35
5	9	13	6	1	1	0	30
6	6	16	2	0	5	0	29
Total	75	96	36	16	10	0	233
%	32.19	41.20	15.45	6.87	4.29	0	

Lower order: 32.19% + 41.20% + 14.45%= 88.84%; Higher order: 6.87% + 4.29% + 0% = 11.16%; Lower order: Higher order = 88.84: 11.16

From the above table it can be seen that most of the objectives outlined in the textbook are of the lowest level while very few are higher order objectives. This shows that the Grade 11 chemistry syllabus developers did not give attention to Bloom's taxonomy of educational objectives. The following example was taken from Grade 11 chemistry textbook to illustrate the process of analysis.

Example. 1.1 THE SCOPE OF CHEMISTRY

Objectives: After going through this sub unit, you will be able to:

- define chemistry;
- appreciate the use of chemistry in the study of other fields;
- explain major branches of chemistry;
- identify the scope of different branches of chemistry.

The above objectives are categorized in lower order according to Bloom's taxonomy of educational objectives.

Students Involvement Index for Figures and Diagrams in Grade 11 Chemistry textbook

Description and Rating the Figures and Diagrams in the textbook

a. Description

1. Each figure and diagram was analyzed using the following categories.

a = used strictly for illustrative purposes.

b = requires students to perform some activity or to use data.

c = fits none of the categories.

2. Calculate the index of student involvement for the figures and diagrams:

$$\frac{b}{a}$$

b. Rating the Figures and Diagram

Table 2 shows the rating of figures and diagrams in the textbook.

Table 2. Rating the Figures and Diagrams

Unit	Categories		
	Passive Involvement (a)	Active Involvement (b)	Student Involvement Index (b/a)
1	6	0	0
2	16	0	0
3	23	0	0
4	10	0	0
5	9	0	0
6	10	0	0
Total	74	0	$\frac{o}{74}$ =0

As can be seen from the table there is no figure and diagram that involves students in the textbook. This indicates that all the figures and diagrams were drawn for illustrative purpose rather than for performing activities.

Examples

The following figures were taken from grade 11 Chemistry textbook as an example.

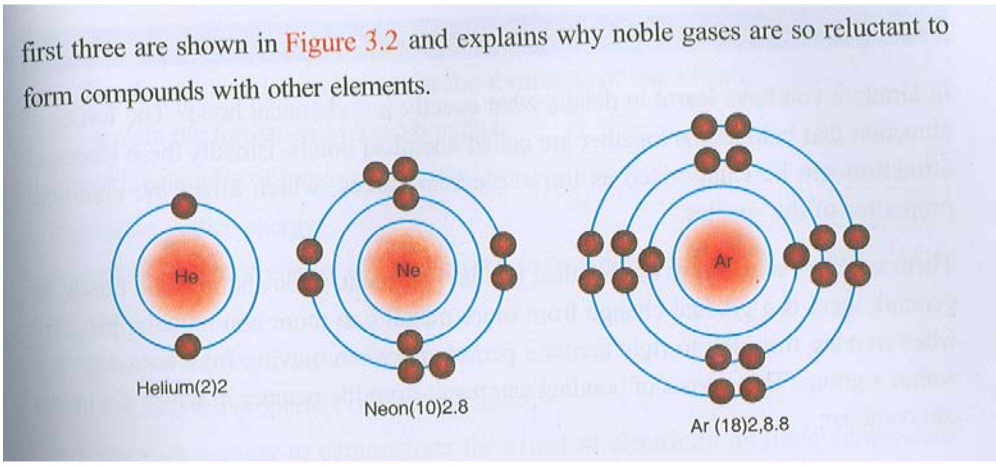
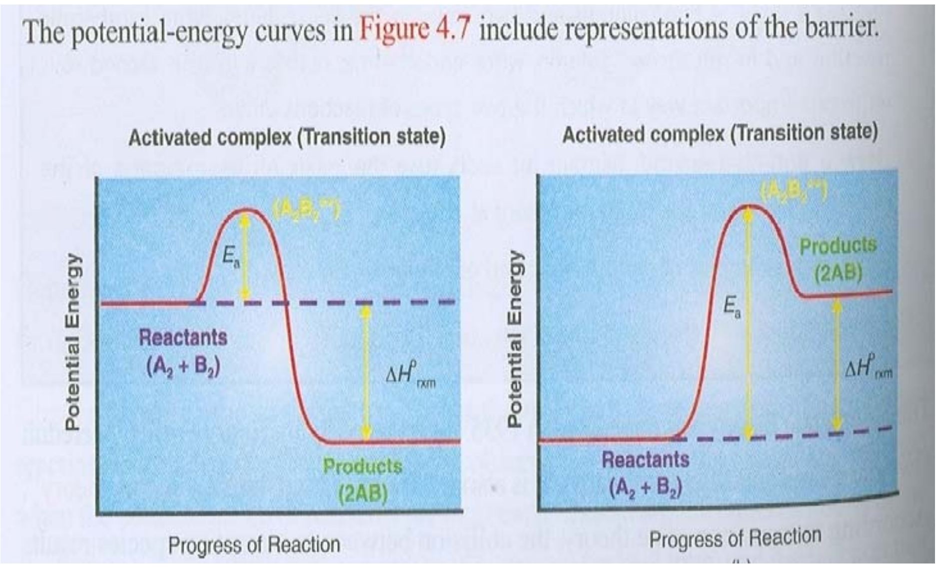


Figure 3.2 in the textbook shows the electronic configuration of the first three noble gases. But instead of arranging the electrons students could be asked to complete the table to involve them in the teaching learning process.

The following figure shows reaction energy diagrams for exothermic and endothermic reactions. Since the students learned about this in lower grades, they could be asked to draw the diagram by themselves.



The involvement level of activities in grade 11 Chemistry textbook

As discussed in the methodology part, in order to analyze the activities suggested in the textbook the inquiry level index for activities was used. Table 3 presents the results of the analysis.

Table 3: The Involvement Level of Activities in Grade 11 chemistry textbook

	Passive involvement	Active Involvement			Total
Unit	Level 0	Level 1	Level 2	Level 3	
1	_	3	7	_	10
2	_	23	5	_	28
3	1	20	1	_	22
4	_	7	2	_	9
5	_	9	1	_	10
6	_	13	1	_	14
Total	1	75	17	_	93
%	1.07	80.65	18.28	_	100

According to Table 3 above, Grade 11 chemistry textbook contains only 1(1.07%) passive involvement i.e. level 0, 75 (80.65%), level 1 and 17 (18%) level 2 activities which are categorized as active involvement. There is no activity categorized as level 3. This shows that even though there is no level 3, the activities in the textbook encourage students' involvement.

Example Activity 2.6 from grade 11 chemistry textbook

Form a group and discuss the following questions and share your ideas with rest of the class.

1. Are neutrons present in all atoms?
2. Can two atoms have same number of electrons but different number of neutrons?
3. Can an atom have unequal number of electrons and protons?
4. Chemical properties of an atom are decided by number of electrons, protons or neutrons?

5. Define atomic number and mass number. Which one can vary without changing the identity of the element?

According to Heron (12), the questions given in activity 2.6 above are categorized under level 2 because only questions are given but procedures and conclusions were left for students. So, the activity involves students.

Students Involvement Index for Texts Chemistry textbook

Table 4 below shows that only unit 4 of grade 11chemistry textbook has average with 0.5 student involvement value. The other five units have below average. This indicates that there is very low students involvement in the knowledge presented in the texts of the indicated chapters. So, they are designed exclusively to promote learning by rote.

Table 4: The Involvement Index of Text of Grade 11 Chemistry Textbook

Unit	Categories						Romey's Involvement Index	
	Active Involvement			Passive Involvement				
	S(a)	UITQ (b)	RE (c)	C(d)	AITQ (e)	URE (f)	SII= $\frac{a+b+c}{d+e+f}$	Remark
1	-	-	7	22	-	-	0.32	Below Average
2		2	-	29	1	-	0.06	Below Average
3	-	3	4	52	-	-	0.13	Below Average
4	-	7	2	17	1	-	0.5	Average
5	-	-	2	21	-	-	0.09	Below Average
6	-	-	6	14	-	-	0.3	Below Average
Total	-	12	21	155	2	-	0.21	Below Average

S= skills, UITQ = unanswered in text questions, RE = real examples, C=concepts, AITQ = answered in text questions, URE = unreal examples, SII = students involvement index

The Involvement Level of Questions in Grade 11 Chemistry Textbook

Table 5: The Involvement Level of Questions of Grade 11 Chemistry Textbook.

	Categories			
Unit	Passive Involvement	Active Involvement		Total
	Literal	Inferential	Critical	
1	10	-	15	25
2	15	11	7	33
3	20	16	-	36
4	21	5	3	29
5	8	2	10	20
6	10	7	-	17
Total	84	41	35	160
%	52.5		47.50	

As can be seen from the table, a total of 160 questions were analyzed. Of the 160 questions, 84 (52.5%) were lateral questions and fall in the category of passive involvement. This shows that more than half (i.e. 52.5%) of the questions in the textbook do not seem to be engaging the students in meaningful thinking since the answers are readily available and explicitly stated in the text. The remaining 76(47.5%) fall in the category "active involvement' which require higher order thinking.

Example. Exercise 3.4 in grade 11 Chemistry textbook

1. Explain the formation of bonds in the following pairs of elements:

a potassium and chlorine,

b magnesium and oxygen and

c sodium and oxygen.

2. Which of the following elements will form a ionic bond with chlorine and why? Magnesium, Carbon, Oxygen and Silicon
3. Why ionic bond is also known as electrovalent bond?

The above questions are categorized as literal questions (see appendix I).

RECOMMENDATIONS

During Chemistry textbook preparation or/ and revision, active learning methods need to be incorporated adequately so as to achieve the aim of chemistry education. Hence, all responsible bodies should deliberately consider the following as benchmark during textbook preparation or/and revision to realize the intentions in the Education and Training Policy.

- To increase students' involvement the knowledge presented in texts should incorporate tasks that require skills telling to analyze and synthesize activities. Unanswered in-text questions requiring data analysis and real examples related with students' lives might help the development of students' knowledge and skills.
- Activities in textbooks which take into account the need for 'level 2' and 'level 3'activities help students exercise their critical and creative thinking skills. Such skills are necessary for solving problems in life and academic situations. Chemistry textbooks are useful if incorporate such activities.

- In addition to inferential questions textbooks should also incorporate critical questions that ask learners to express their views and opinions by using their higher order thinking;
- Figures and diagrams illustrated in chemistry textbooks should enable pupils to engage actively with lessons to develop their thinking and interpreting power.

REFRENCES

1. Nunan, D. (1998). The learner Centered Curriculum. London: Cambridge University Press.pp98-99.
2. Tesfaye Ejigu (2005). Techniques of Writing and Editing Educational Materials. Addis Ababa:Eleni Printing Press.
3. Romey, William (1968). Inquiry Techniques for Teaching Science. London: Printice-Hall.
4. Fletcher, R., 1974. An Application of Romey s Involvement Index and a standard of reading Formula to Representative Modern and Traditional Science Textbooks for Grade7-10. Retrieved on 15/01/2010 from Htt //www.eric.ed.gov/ ERIC Web portal/ record Datail.
5. Robert, A., 1962. The Teaching of Science in the Upper Primary School**:** *African Education Journal .7 (2): pp9-20. Lusaka.*
6. Solomon Amare. (2003). Peer Review of Instructional Practice at Colleges. IER Flambeau. 11(1):43-59.Addis Ababa University.
7. McNamara (1994). Classroom Pedagogy and Primary Practice. London: Selwood Printing Press Ltd.3p.
8. Mehari Yimulaw (2007). Modules and Active leaning. *The Ethiopian Journal of Education.* XXVII (1): pp73-86. Addis Ababa.
9. Bullington, A. (1962). Teaching of Science in the Upper Primary School. *African Education Journal.* 7(2): 9-20. Lusaka.
10. TGE (1994). Education and Training Policy of Ethiopia. MoE: Addis Ababa pp1-5
11. MOE (2009). Strategies For Improving Science and Mathematics Education in Ethiopia: Addis Ababa (unpublished). Pp.1-5.
12. Herron, M.D., 1971. The nature of scientific inquiry. *School Review*, 79, 171- 212.

APPENDIX I

The description of categories under each of the four components of the text books

A. Texts

1. Active involvement texts: when students engage actively in learning process with skills (procedural knowledge), real examples and unanswered in-text questions.

1.1 Skills: are procedural knowledge demands both in and out of classrooms abilities which include observing, measuring inferring, predicting, classifying, collecting date, recording data, interpreting data, controlling variables, formulating hypothesis, comparison, construction, experimentation, identification and sorting.

1.2 Real examples: are supporting evidences those, most meaningful and relevant to students live, needs and interests and provide opportunities to experience and understand the practical applications of the science concepts and procedures and resulting social applications.

1.3 Unanswered in-text questions: are in-text questions that does not answered immediately in the text and made the learner to stop and think for a moment.
2. Passive involvement texts: when students engage passively with concepts (conceptual knowledge), unreal examples and immediately answered in-text questions.
2.1. Concepts: are conceptual knowledge s which include ideas, principles, laws, facts, rules, generalizations, theories that scientists have developed and accumulated with the procedural inquiries. These concepts are stated in the texts and summaries and learned by rote.
2.2. Unreal examples: are examples that are not relevant with students real life and social applications. These examples do not give opportunities to experience in the practical applications of science concepts and procedures.
2.3 Answered in-text questions: are in-text questions that answered immediately in the text with a formal written answer.
3. None of these: a paragraph or entire of subtitle that not fitting neither of skills nor concepts.
B. Activities
1. Passive involvement activities: activities labeled under level 0 which are structured with given or closed problem, procedure and solutions.
1.1. Level 0: an activity or task where problem, procedure and conclusion is all given and the only task remaining for the student is to collect data.
2. Active involvement activities: Activities labeled under level 1, level 2 and/or level 3 which one or more of problem. A procedure of solution is open to learner s investigation.
2.1. Level 1: an activity or task where problem and procedure are given and the student has to collect the data and draw the conclusion
2.2. Level 2: an activity or task where only the problem is given and the student has to design the procedure, collect the data and draw conclusion.
2.3. Level 3: An activity or task where the student has to do ever thing by themselves, beginning with problem formulation and ending with drawing conclusions.
3. Not clear: activities which are not clear to categorize under either of the above four level of activities.
C. Questions
1. passive involvement questions: are answered by lower order thinking of learners which require them to recall simple facts or information previously taught.
1.1 Literal question: a question which has answer that can be located in the reading selection and require minimal use of prior knowledge and stated facts to be recalled for comprehension.
2. Active involvement question: are answered by higher order thinking of learners and which require students to formulate, evaluate or synthesize an idea and provide logical response.
2.1. Inferential question: Question which has factual answer, even though the answer may not be certain. It requires the two or more facts be considered together in order to produce an unstated (suspected) facts.
2.2 Critical question: a question which has answer that are not facts but that reflect values. It needs synthesizing information from a variety of sources in order to apply it to a new situation, solve problems, identify biased writings etc.
3. Not clear: Questions which are vague questions to categorize under either of the above three levels of questions.
D. Figures and diagrams
1. Passive involvement figures: figure, diagram, picture, drawing, photograph, etc which is constructed only for illustrative purpose

2. Active involvement figures: figure, diagram, picture, graph, drawing, photograph, etc which requires students to perform certain activity to answer question and exploring something.
3. Not clear: Figure, diagram, pictures etc which are not clear to categorize under either of the above two categories.

AFRICAN JOURNAL OF CHEMICAL EDUCATION

AJCE

GUIDELINES FOR AUTHORS

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.