HOW CAN I IMPROVE MY STUDENTS' ABILITY IN DOING LABORATORY PRACTICAL WORK ON ANALYTICAL CHEMISTRY-I? A CASE ON CLASS N23 AT KCTE

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ABSTRACT

From my experience of teaching in KCTE and class N23 (Natural science department, year 2 section 3) in the years of past time, these students were active in class participation and did what was given to them in theoretical approach. However, they were getting confused specially on the concepts requiring applications during practical laboratory activities. They lose their individual confidence of handling and manipulation of apparatus and chemicals. That was why I chose them specially in doing Practical Analytical Chemistry-I (Chem 223) of the semester. This action research was aimed at improving students' ability in doing the practical laboratory work and exercising of science process skills. This was because these students show lack of experience in specially handling laboratory materials, chemicals and following scientific processes like observation, data record, analysis, measuring and following of appropriate safety rules while working in lab independently or being in groups. In this study, observation, questionnaires and tests were used as tools to gather information about the participants for both pre-and –post interventions. It was seen from the study that students feel more interactive and confident when working in group rather than independently. This has also boomed students` experiences as it was multi-side interaction between student-student, student-teacher and teachers-teachers as well. This study reveals that students' achievement improved from 52.37% to 70.21% on questionnaire, 68.06% to 84.44% in test and 69.47% to 72.50% in assessment which covered lab class activity, practical show activity and report writings. In general, it will be better for instructors like me to plan "starting-ongoing-ending" and "cooperative learning" approach while designing the practical lab instruction to enhance students' learning. *[African Journal of Chemical Education—AJCE 5(1), January 2015]*

INTRODUCTION

I have been teaching this course since 2009 at least once a year. And from my teaching experiences, I know that this course contains ion analysis, acid-base theories, solubility, redox reaction and complex equilibrium. I have been teaching two courses before and I`m teaching two courses by now for N23 students, of which two courses are laboratory practical work.

The students participate in class, engage themselves in different class activities like asking questions excessively, group works, etc but with low score on individual assessments and show the behavior of confusion while laboratory practical work was implemented. This and other related learning behavior of these students initiated me to conduct this study.

Some studies [1] argue that chemistry is perceived as a very difficult subject by students due to its abstract concepts. This is most often attributed to the challenges that they face to construct the abstract concepts that they frequently encounter in the subject area. In such a way it profoundly influences students' selection for subject of preference or as area of specialization. Others [2] explained in their study that laboratory applications are of significant importance in chemistry education. However, laboratory applications have generally been neglected in recent educational environments for a variety of reasons.

To me (and to my work colleagues in natural science department of KCTE, I believe) teaching science without practical manipulation in laboratory is teaching an impaired science. It is a science with one sense organ removed. Hence, in order to address the gap, it is important especially by their instructors to pay critical attention for practical laboratory instruction and take the remedial action to minimize this gap, I believe.

Our College (KCTE) being newly established and not well equipped with laboratory materials, it is trivially concluded that most science works are covered theoretically, even though it should be practical conceptually. Hence, now a day, our College is emerging with on/off access of internet services. And our college uses linkage of *practical only work linkage* under strict and spoon feeding style with Kamise Town Preparatory School (KTPS). Being one of the teachers of the department, I feel that there is huge gap between the concepts to be thought and the teaching-learning process used in practical work class. Thus, this initiated me to consider this study which mainly focuses on the following questions:

1. What will challenge students' ability in doing practical lab work?
2. How can I improve students' ability in doing laboratory practices?
3. What science process skills will students gain as practical method(s) of teaching laboratory intervened?

The main objectives of this study were:

1. To identify major challenges that students face in doing practical laboratory work on Chem 223
2. To device method(s) that help tackle with these problems.
3. To improve students ability in science concept and practical laboratory process skills.

SIGNIFICANCE, ETHICS AND DELIMITATION OF THE STUDY

Science is the base for well being of every world in every aspect like economically, socially and politically. And all these aspects are the field of competition among nations. As stated in previous study [3], the one with better adjustment and most competent from the many is the champion of surviving to continue the competition.

Same concept works to me and my students too, I believe, as long as being part of the population. This study can add certain science concepts, science process skills required specially for laboratory practical works and safety rules which enable them to work at primary schools in their occupation.

Learning pyramid [4] illustrated educators' perceptions regarding students learning as they found that: students retain percentage as following ways:

Learning behavior	**% Retained**
Hear	5
Read	10
Demonstration	30
Discussion	50
Practice	75
Apply and teach	90

As mentioned in the table, concepts applied in daily work and involved in practical work will be retained long by students` mined. Hence, it is practical laboratory which plays a great role in this aspect especially in science teaching as revealed by this study. On the other hand, scholars [5] explained that individuals' brains will not retain 99% of the information they receive. This has raised a surprising question which was stated as "Consider the vast amount of information that bombards an individual in a single day", but the students retain only about 1% of all. From this and the table provided above, it is clear that practical and application ways of learning like that of laboratory methods are the leading approach to enhance and meet leaning styles of students besides professional satisfaction.

All sources data for this study were respected, information was quoted, and sources were mentioned exclusively. Participants of the study were communicated and briefed with the objectives of this study. Neither data was collected nor displayed in the absence of common agreement with the participant of the study.

This study was conducted in KCTE being with chemistry major English medium 2nd year students of 2014. These students were attending the course Practical Analytical Chemistry-I

(Chem 223). Therefore, this study was implemented in Semester-I of the year in the fore mentioned class by the subject teacher.

Most limiting factors were lack of chemical and apparatus required for the lesson, on/off internet services (access), and lack of virtual chemistry software and insufficient manipulation skill for its application.

LITERATURE REVIEW

Learning is a gradual behavioral change. This can be manifested through the way one acts (feeling, expressions, and communications), what one can do and the way one can offer others to act. It develops through different level of ages. The lower level education serves as the development of experience for welcoming of the upper level of learning.

However, studies show that students have difficulties in understanding scientific concepts across all levels of ages. This gets more aggravated in developing countries. Hence it needs science teachers to support students explore the science concepts and process skills. It was argued [6] that in chemistry, being one of the branches of science, teaching its concepts must be designed to incorporate experimentation, observation and other laboratory oriented activities or disciplines. This study also suggested that if we want our students know what and how other chemists (science scholars) do and get them involved in science fun, we have to be able to let them practice science processes activities like observation, measurements, comparisons, classification and evaluation. This is based on the facts that science (chemistry) education is an involvement and understanding of the science processes. Hence the effective use of laboratory is required to make science education successful. In general, laboratory teaching is important in science like that of chemistry as it plays great role in:

- developing science process skills and
- having best experience of what science is.

This implies that even when there is no well equipped and well organized laboratory in schools and higher education institutions like KCTE, it is important to give attention for improvising of laboratory equipments (and chemicals) locally from low cost or no cost available resources. It was forwarded [7] that laboratory practical in their ways of definition and operations means active and interactive approach of teaching-learning process and taken as valuable tools in maximizing the learning experiences of both students and staffs.

1. **Benefits of laboratory practices**

A previous study [7] has summarized that investigative/inquiry based laboratory practices have potentials to develop students`:

- understanding of concepts
- scientific applications
- scientific attitudes
- practical skills
- problem solving abilities
- scientific habits of mind
- understanding how science and scientists work
- ability to formulate scientific questions
- ability to form hypotheses
- ability to design and conduct investigations
- ability to formulate and revise scientific explanations
- communication skills and/or ability to defend scientific arguments

- interest and motivation
- skills in teamwork
- imagination and creativity
- technical skills in the use of equipments

2. Common challenges of laboratory practice

From experience of teaching in schools and college in the previous years, I found that teaching and learning process of laboratory practical in science was not an easy task. For one thing, the misconceptions of students in science devotes the energy; on the other hand, lack of laboratory experience, exposure and science process skills hinders students from attaining the objectives of laboratory practical designed.

Scholars [7] explained in their study that although laboratory practices enhance the students' learning experience, it has also been criticized for the fact that it is unproductive and confusing unless clear thought used. It was suggested that cultivation of students' intellectual skills should be given attention to enhance learning rather than following "cookbook" approach. Hence poorly involved and experienced students developed poor or no experience of laboratory management even for highly expensive chemicals and apparatus. It is common especially in our college that students' involvement for practical manipulation of these substances is rare in laboratory. This is due to lack of well organized laboratory, large class size, students science background, proximity of practical and theoretical class, availability of standardized laboratory books and poor skills of application of IT for laboratory practical as I confront them in my daily experience of work.

3. Good laboratory practical designs

Some studies conducted previously [8] suggested that when designing or supervising practical/laboratory work, it is recommended that one should leave behind the "cookbook" approach and try to:

i. *Foster student independence and growth*. It is better to support them in highly challenging situations, encouraging active participation and remove or avoid long time of standing around in an observational capacity.

ii. *Enhance students' learning.* Emphasize critical thinking, problem solving, scientific inquiry and other activities that create opportunity for students to think.

iii. *Encourage the integrity of the practical classes* with the theory and learning thought in other aspects of the courses and classes.

iv. *Facilitate, don`t lecture.* Avoid telling students the facts but help them to find the answers by questions, experimental designs and the like.

v. *Have coordination* of practical activity, pre-practical tutorials, report writing methods, practical designs explained for students prior to practical starts.

METHODOLOGY

Sample and sampling methods

This study was conducted on year-II chemistry class students. In this class, there were 23 male and 1female students and all of them were involved on the study. The sample size consists of all the 24 chemistry class students purposively selected. They all take the practical analytical chemistry-I (Chem 223) and were attending their study being in the same class in KCTE. This subject was selected for this study because it contains vast number of experimental works, safety rules, precautions, and taken by all of these students in this semester. Hence, it was one of the areas where students could apply what they have been learning in the previous courses like Practical General Chemistry-I&II (Chem 103 & Chem 104), respectively. In addition, it creates wide opportunity for me to look through the students` laboratory skills and learning behaviors.

Study Variables

This study uses as a variable on **science concept** and **science process skills** improvement by the participants during the practical work in lab class. The science concepts focus on the application of previous knowledge by the participants on the areas of safety rules, following the scientific method during practical work and scientific report writing. Science process skills, on the other hand, involved the application and utilization of both the basic and integrated science process skills. All these were investigated through study instruments during the whole process of pre-intervention and post-intervention.

Study instruments

To collect data, I used different tools like questionnaire, test and observation/assessments. The questionnaire consists of seven items, all explaining the application of science concepts (theories, laws and principles), and science process skills. The test was developed to identify the students' challenges in doing laboratory practical work using the knowledge that they have learned before. Observations were made through practical class work, home taken work and writing science report. For each and every activity given to them, they were marked and the results were recorded accordingly.

Data analysis methods

All data were organized after collection in the way appropriate for analysis and easy for the reader(s). Hence, I used tables to organize data and explained them within table using numbers and percentages. This was used to compare the results of the collected information(s). Finally, data were displayed in graphs to compare the changes or difference in learning skills and behavior before and after implementation of the remedial action(s).

DATA ORGANIZATION, ANALYSIS AND DISCUSSION

Pre-intervention data

1. Questionnaire

Nine differing practical work were planned to practice by students. Five of them were used for pre-intervention and the rest four were used for the post- intervention practice. Hence after instruction of the five practical works, the question containing seven items was developed and delivered for students to tick against their degree of acceptance for the concepts of each item. Then I counted the total number of students in each item. A scale of 4=strongly agree, 3=agree, 2=disagree and 1=strongly disagree were used as representation for the provided items.

At the head of the last main columns in the table, NAC is used to represent Not Accepted the concepts contained by the items and AC is used to represent Acceptance of the concepts contained by the items listed under focus points.

Table 1 Percentage Acceptance of students for questionnaire items

S.N	Focus Points	NAC		AC		%AC
		1	**2**	**3**	**4**	
1	Taken the sample and reagents using dropper, Pipette, Burette Or by tilting the Beaker	1	12	6	3	37.5
2	Registered (recorded) what is seen from experiment as Text, Table, Drawings or own abbreviation during the practical work.	3	4	8	9	70.8
3	Precipitations (ppt) formed, color changed or Both during the experiment.	1	6	9	8	70.8
4	The following properties: Concentration, Volume, Drops, Mass or Temperature of the sample have been measured during the experiment.	11	7	5	1	25
5	Any calculation of the results has been done during lab/ during report writing.	5	9	5	5	41.66
6	Graphs, tables, or others used to explain what observed from the experiment.	2	8	12	2	58.3
7	Working table and all apparatus cleaned before, at the end or both time of the experiment.	4	5	9	6	62.5
	Average					52.37

Where NAC=Not Accepted the items and AC= Accepted the items

Out of the seven items, the highest score was 70.8%, for items 2&3, and the lowest score was 25% for item 4. This implies that students practiced more on the concept of item 2 and 3 while they practiced least on item 4.

2. Test

I have prepared theoretical test and practical test questions which were recorded out of 7% and 8% respectively which comprises a total of 15% evaluation. This was intended for the investigation of the application of science concepts and process skills by the students during the practical work.

Example of practical test questions

Students were individually allowed to respond for the practical work questions after they were instructed on theoretical base in class. The following questions were developed and used for the test.

Q1. Write the chemical formula of bubbles of gas evolved when dilute HCl is added drop wise to the solution containing HCO_3^- ion (2 points).

This question was answered by 5 students as no formation of gas seen, CO_3^-(g), Cl_2^-(g) and Cl^-(g) gases formed while 19 of them answered it as CO_2 . In this question, it was expected from students to apply the theoretical concepts learned in class before the practical application in laboratory room and relating of pre-requisite knowledge. As it was explained above, some of them yet need support in:

i. Theoretical background revision in order to work on application in practical class.

ii. They need to distinguish the difference among gaseous substances and ionic specious.

Q2. Set up test for Na^+ ion (3points).

In doing the practical test for the Na+ ion , majority of them over pass the rinse of the Nichrome wire (substituted by Cu-wire) with HCl. This led them to miss the conclusion that both known sample solution (solution of NaCl) and unknown sample solution ($BaSO_4$ solution) contain the Na+ ion.

In general, the summary of the results from the two tests was organized as the following table using their ID.No instead of indicating their names.

Table.2 Test scores for pre-intervention

S.NO	ID.NO	Pre-Int Score
1.	NSR-AL/0118/05	14
2.	NSR-AL/0119/05	5
3.	NSR-AL/0122/05	1
4.	NSR-AL/0123/05	10
5.	NSR-AL/0130/05	14

6.	NSR-AL/0132/05	12
7.	NSR-AL/0135/05	7
8.	NSR-AL/0136/05	11
9.	NSR-AL/0138/05	11
10.	NSR-AL/0141/05	12
11.	NSR-AL/0150/05	15
12.	NSR-AL/0143/05	5
13.	NSR-AL/0128/05	14
14.	NSR-AL/0140/05	11
15.	NSR-AL/0147/05	5
16.	NSR-AL/0151/05	13
17.	NSR-AL/0137/05	10
18.	NSR-AL/0125/05	12
19.	NSR-AL/0121/05	8
20.	NSR-AL/0148/05	13
21.	NSR-AL/0117/05	9
22.	NSR-AL/0139/05	9
23.	NSR-AL/0134/05	11
24.	NSR-AL/0120/05	13
Average		10.21
Percent		68.06

It is trivial to calculate from the table displayed above that students scored 10.21 on average which is approximately 68.06% of the expectation from the test. Finally the students were classified based on their scores for the sake of comparison as Low score (0 to 5), Medium score (6 to 10) and High score (11 to 15) based on their achievement results as follows.

Table 3 Categories of students based on their test achievements.

	Low score	Medium score	High score
Number of students	4	6	14
Relative percent (%)	16.67	25	58.33

As could be deduced from the table above, majority of the students (58.33) scored high. But there were students (41.67%) who need support and scored less than pass mark of the point (7.5). These are found at the category of low and medium scorers. This way I have categorized students using their scores on the test coded with their ID No**.** This helped me to explore who needs support on which concept and process skills for the remedial action to be taken. It also helped me in planning intervention actions. For instance, it directed me to organize my instructional resources, concepts to be reviewed and schedule time and places according to the students need.

3. Observation/Assessment

Observation of students' different activities during laboratory *practical work in lab, home taken activities* and *lab report writing* was evaluated and recorded (Appendix-C) using evaluative rubrics for each of the students work.

I. Practical work observation rubrics

Observation rubrics for practical doing of the lab activity was developed and implemented as the following table and the result was ticked against under the degree of implementation where:

0= Not yet, 1=achieved the standard, 2= competent, and 3=Highly Capable

Table 4 Observation rubrics for practical activities

S.N	Focus Points	0	1	2	3
1	Objectives, concepts and what / why to do is understood.			√	
2	Test tube& Work instruments cleaned, Table and working space cleaned, Working apparatus and chemicals named				√
3	Procedurally work sample and solutions prepared, Appropriate sample size taken, droppers/spatula used		√		
4	Steps followed (lab manual) chemicals and apparatus taken, reagents and samples identified, appropriate amounts mixed.			√	
5	Observations, reactions and events recorded (asked for help etc) as Text, graphs tables or charts		√		
6	Appropriate reaction results written or personal abbreviations used		√		

When students were asked to start the practical work, they lose self confidence and stand a while until their friends begin the task. It seems they get confused with objective of the experiment. Some of them used excess amount of reagents and samples. The others used the same dropper for both the reagents and the sample. It was also seen that some students were trying to use the large sized Brush to wash test tubes which was unfitted. They forgot also to follow the manual instructions and simply added the reagents and the sample together. Three of the students in Group1, for instance, was attending their friends work but not recording what they observed from the experimentations.

II. Lab Report evaluation Rubrics

Table 5 Laboratory report evaluation rubrics

S.N	Focus Points	0	1	2	3
1	Basic information, Titles, Objectives and theories written appropriately			√	
2	Apparatus, chemicals, Guide manuals(other materials, references) mentioned		√		
3	Procedures, safety rules and other precautions focused		√		
4	Raw data, Personal abbreviations and IUPAC Symbols/formulas etc used, recorded as either Text, graphs, tables etc				√
5	Analysis- calculations, Drawings, Texts, Observations(effects/changes & results) etc explained well			√	
6	Pre-requisites applied, related theories explained, conclusions drawn, etc		√		

Thirteen of them mentioned the course code as "No.223" instead of Chem.223 on the cover of their report while the other eleven mentioned it as Prac.223. On the other hand, half of the participants did not mention their group numbers on their report paper. Majority of the students did not mention all the apparatus used for the experiments and twelve (50%) of the participants listed the chemicals used without indicating their amounts. All of them did not relate the experiment with previous theories, skills learned was not mentioned and hence what they learned from the experiments was not explained at the end.

III. Example of Home taken activities

It was individually and in groups given home trying question after completion of the practical work in lab room. The result was checked, recorded next and hold for each of them individually. The following question is the sample of the questions used for home work assessment.

Q1. Why do we add HCl to a solution of SO_4^{2-} ion before the addition of $CaCl_2$ reagent?

Even thought it was discussed in theoretical classes before, none of them answered it as expected but with the approximate trial, three of them said it as to form of solution of the mixtures of the ions.

The result of the assessment which was used as observation was summarized using tables bellow (see Appendix-C for more).

Table 6 Observation record of students' different activities

	Low score(0-5 points)	Medium score(6-10 points)	High score (11-15 points)
Number of students	0	11	13
Relative %	0	45.83	54.17

As we can see from the table above, all students scored medium and above. That is 45.83% of them scored 6 to 10 points while 54.17 of them scored 11 to 15 points.

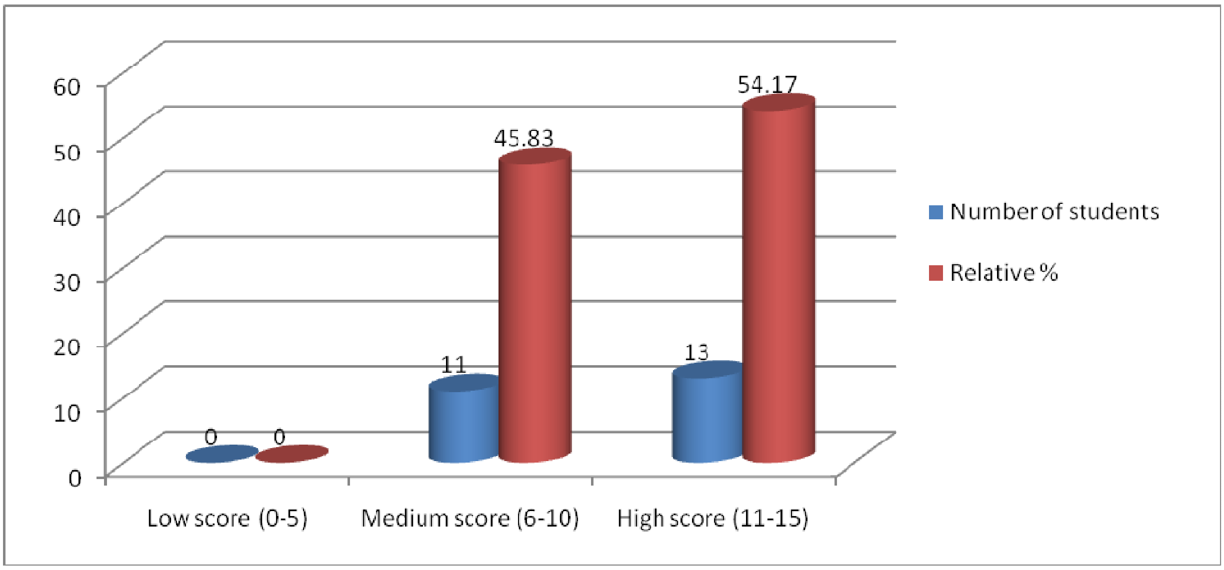

Figure 1 Observation results for pre-intervention

Major laboratory challenges of students

It is common expectation that experimentations will help students understand lecture materials as chemistry is one of an experimental science. In the laboratory, they will go over many practical applications of the theories they learned in class. As to some study [9], use of laboratory practical as a study aid helps learners to understand chemistry and even have fun! However, many students did not enjoy laboratory and did not find it helpful because they faced challenges in doing lab work on practical course like chem.223 among which the major ones listed below.

1. They take a "half journey completed" approach to practical chemistry

Previous studies [9] called this as “a kook book approach to chemistry.” The students did nothing more than follow the recipe without thinking about what was happening in the test tube and how it was related to what they were studying and to the rest of the world in general. In such an approach students let to gather information of lab result by mixing what was already prepared by the Lab Instructor. They did nothing in preparing majority of the laboratory samples.

This was what my departmental colleagues and I accustomed to use in laboratory instructions in our College. They were allowed to learn only the half way completed end results. When students took the cookbook approach in doing the practical work, they were going to have a poor experience in the laboratory and an especially hard time completing their laboratory reports [9].

2. Lab experience matters how and what to do

Students lose confidence in handling apparatus and chemicals in laboratory. Taking chemical from stock solution, mixing chemical to conduct reactions and following appropriate safety procedures were the major areas where they felt complicated task during the practical work. Most of them set their mined with fear which was obviously understandable from the behavior what they do, how they act and even tell to me when asked to conduct the activities by themselves. This in turn hindered them from thinking to apply the laboratory safety rules, theories, principles and laws that they have experienced more theoretically and in the previous courses.

Majority of the students prefer to watch what was going on while few group members did practice the activities and collecting their data. Even when I enforced them to practice it, immediately they committed mistakes. For instance, when I asked them to prepare a solution of the solid $NaHCO_3$ from the stock bottle in conducting test for carbonate ion, most of them take the sample solid and add directly to water in beaker without measuring the grams of sample required on beam balance. Some of them try to stir the mixtures using spatula. The other difficulty which they faced during the test for this ion was relating the concept with what they have learned before. For example, some of them asked me “what is the need of dissolving $NaHCO_3$ because our objective is to test HCO_3^- ? Why we don`t dissolve HCO_3^- directly?” Others asked me that “why white precipitation is not formed when we add Conc. HCl on solution containing HCO_3^- ions?” This implies that lack of experience in handling laboratory equipments, chemicals and practice by themselves saturated misconceptions and poor experience in doing practical laboratory works.

Intervention strategies

1. Safety rules were reviewed every time students did practical work

In any laboratory, safety is paramount [10]. We should take note of the location of safety showers, eye wash stations and fire extinguishers when entering the lab. This implies that the learners should be familiarized with location of the safety materials when doing in lab practice. In addition, students should be instructed what the major types of laboratory accidents can occur, how to manage them, and what care should be taken before they occur. Some studies [11-12] also agree that all students who conduct their research in laboratory should be instructed or take training of the most common chemical safety related with their work.

Hence, I prepared safety guidelines related with each of the experimental activities planned, delivered the copy of them for my students in figures, texts and discussed on each part with them. Then they were directed to read at home and bring with them every time they came to laboratory.

2. Scientific theories, laws and principles which imply the science concepts in relation to the (practical) lesson were reviewed before the practical class begins

For every practical activity to be conducted there should be revision of related concepts (theories, laws, and principles), procedures and safety rules. This way students` misconception and confusion could be reduced greatly while self confidence and motivation to work appraised. These also step up the students' ability in applying science process skills and previous knowledge during practical work.

3. Students were supplied with appropriate resources like laboratory manuals and safety guide

Laboratory manuals provide students with course title (course code), laboratory lessons (practical activities), working procedures, required apparatus and chemicals, report writing formats, pre-lab and post-lab activities and chemical safety. It comprised revision of related concepts; and outlined the outcome of the lesson for each practical activities designed. Hence it was important that students provided with these materials. In addition it saved time for me in such a way that they read it at home and took short notes about what they are going to do in laboratory. This also opened opportunity to discuss on the concept with their friends and read additional references as required. Therefore, it built good background for the learners before starting the experiments.

4. Students peer work was strengthened in laboratory

As a general rule, working alone is not preferred in laboratory. This was one of the chemical safety rules to be followed because it opens opportunity to help each other in case there safety hazards occur. On the other hand, working together was preferred because two minds (intelligence) were more powerful than one. Students can feel more confident and motivated to work when they were with their friends (the one they know more). This helped them share ideas, reduced accidents and let them learn more. Hence, for more effective practical learning, it showed me that it was better if students' cooperative work encouraged.

5. Practical work was supported with virtual resources

Graphs, figures and video clips used to clarify the flow of ideas, working procedures and procedure of data analysis by both students and Laboratory Instructor (LI) in practical work. Hence these were included in lab manuals and guides during the practice. Videos were used to elaborate concepts, process skills and safety procedures in lab work. These resources were adopted from online resources.

Post-intervention data

1. Questionnaire

Similar questions were delivered to students to investigate if there was any change after intervention regarding each challenge identified. Finally, the following results were summarized as follows (see Appendix-A). This table provides the relative percentage of students that agree with the acceptance (AC) of the practicability of activities outlined from 1 to 7 along with the average of the whole.

Table7 Triangulation of post-intervention data.

Items	1	2	3	4	5	6	7	Average
%AC, Pre-inter.	37.50	70.80	70.80	25.00	41.66	58.30	62.50	52.36
%AC, Post-inter.	70.80	83.30	70.80	54.16	54.16	75.00	83.30	70.22

From this table it could be inferred that students practiced more on each item. This could also be deduced from their average acceptance for the concept of each item that they have practiced. Hence, the average acceptance for practice was 52.36% for the pre-intervention while it was improved to 70.22% after appropriate action intervened. These imply that they agree with the fact that they have practiced the concepts and process skills planned. It could be illustrated using graphs as done bellow.

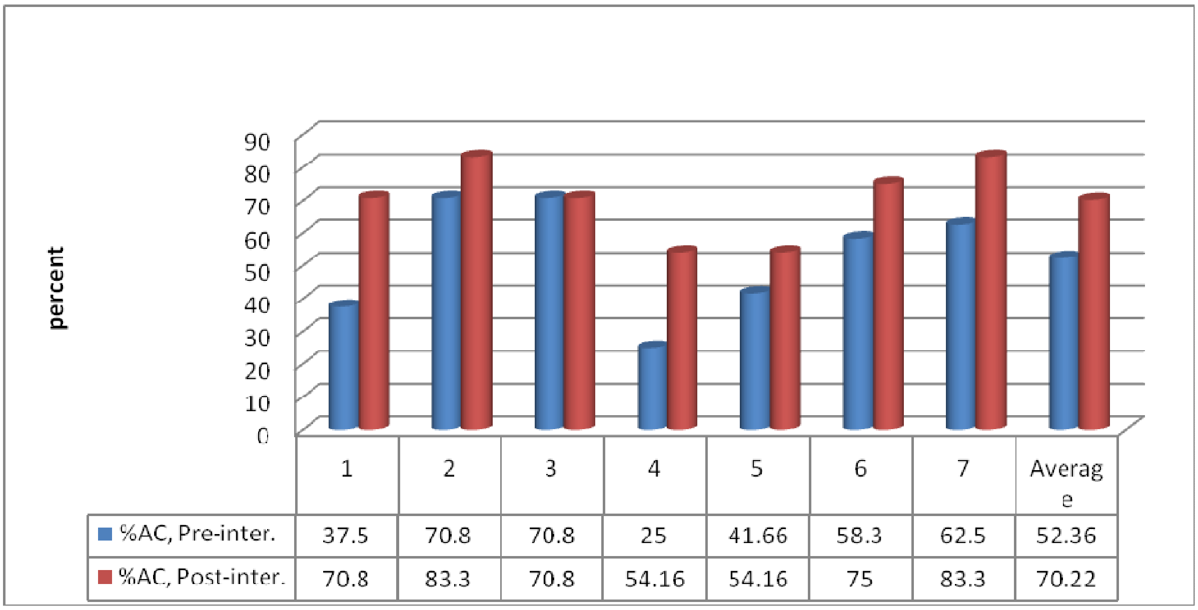

Figure 2 Triangulation of questionnaire data

2. Test

Similar kinds of test questions with the pre-intervention one were used to evaluate students' ability to practice the application of science concepts and process skills after proper intervention was implemented (see Appendix-B). The result was presented as in the following table.

Table 8 Triangulation of post intervention test data

	Pre-intervention data	Post-intervention data
Percentage	68.06	84.44

It could be triangulated using graphs too. The pre-intervention score was 68.06% while the post-intervention value was 84.44% confirming a great improvement.

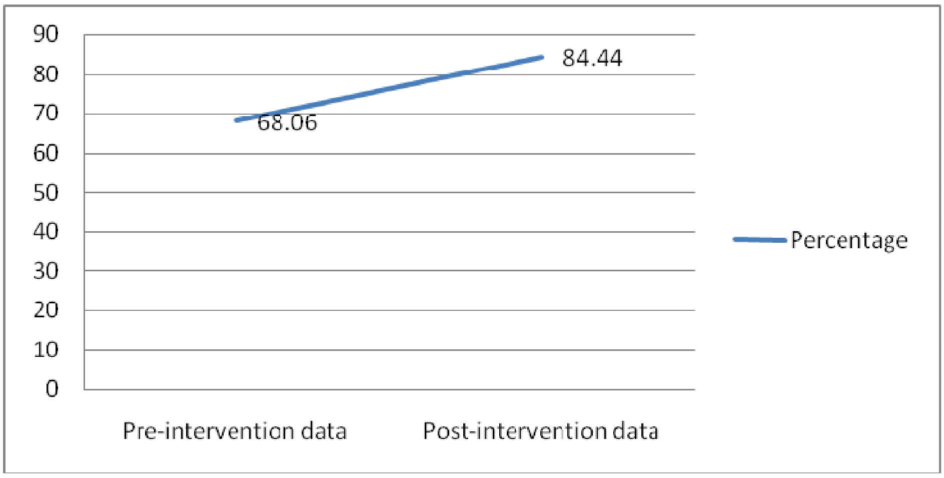

Figure 3 Test data triangulation

3. Observation/Assessment

All data was collected during the implementation of the planned intervention strategies. For this purpose, students' practical class activity, home taken work, and writing report of their work (scientific report writing) was evaluated and the results used to compare their progress (see Appendix-C).

Table 9 Triangulating data for observation of students` activity

	Pre-intervention data	Post-intervention data
Average	10.40	10.88
Percentage	69.47	72.50

From this table, students` achievement in doing practical activity was improved from 69.47% at pre-intervention to 72.50% of the post-intervention. Graphically, the results were triangulated in the following way.

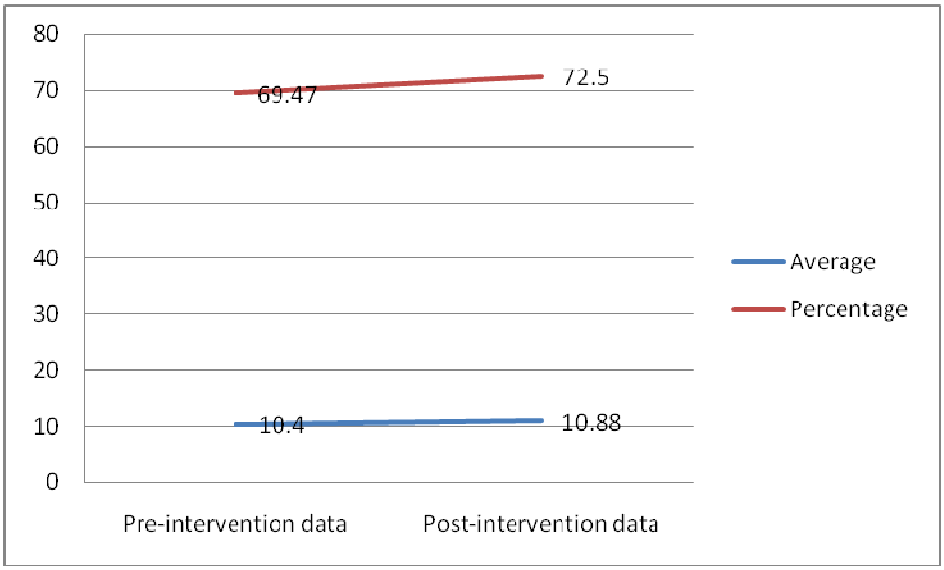

Figure 4 Triangulating Observation data

RESULTS AND DISCUSSION

Through the conduction of this study, I found my students encouraged more doing the practical activities. Initially, majority of them were waiting for their friends to do any kind of the practical works they were allowed to exercise in lab. Each of them preferred watching and recording what was going on and the final products (resulting data) rather than doing it by themselves.

In general, after implementing the intervention actions planned, the following improvements were achieved.

1. The process skills improved

Observation

Students were able to conduct Observation-Based Logic which enabled them to interconvert different levels of thinking in such a way that their *macroscopic-level observations* were connected to science-based mental models of "what was happening" in *submicroscopic-level events* (like the interaction of atoms, molecules, reagents and ions) and their *symbolic representations* (as *verbal* words, *visual* pictures, *personal abbreviations*, *chemical* symbols & reaction-equations,). This in turn strengthened their thinking skills using *Imagination* required to interconvert observations (what they hear, see and read from the experimental activities) with mental models. This ability was applied for understanding the concepts of chemistry especially in solving and doing home taken practical questions.

This was improved greatly inter-conversion skills of students between observation and imagination which made mental connections between different levels of thinking (macro, micro, symbolic). These imaginations led them build mental representations of chemistry concepts and provided opportunities for students to observe-and-imagine. This way practicing the lab practical work and conducting attentive observation, they upgraded their observation and representation ability after intervention (see the following samples taken from their work).

Table 10 Students` observation records

Test for	**Reagents used**	**Results observed**	**Representation/ explanations given by the students**
Chloride ion (Cl^-)	$AgNO_3$(aq)	White ppt,	Cl^-(aq)+ $AgNO_3$(aq) → AgCl(ppt)+ $NO_3^-(aq)$
Sulphate ion (SO_4^{2-})	$BaCl_2$(aq)	White ppt.	SO_4^{2-}(aq)+ $BaCl_2$(aq) → $BaSO_4$(ppt) + $2Cl^-$(aq)
Bicarbonate ion (HCO_3^-)	Conc. (?) HCl	Bubles evolved	HCl(l)+ HCO_3^-(aq) → H_2O + Cl^-(aq) + CO_2,gas
Potassium ion (K^+)	Flame , HCl & Copper wire	Violet colors	Heat + K^+-ion gives violet color

Some of them used their own way of representing the changes under gone after applying the agents and the others represented using reaction representations for what they observed (see, understand) from the experiments conducted.

Measurements

Students were accustomed to take samples and reagents excessively by eye droppers before intervention. Some of them even tried to take the chemicals by tilting the container holding it. But after intervention, they were able to measure the appropriate sample using measuring cylinder of differing sizes and the reagents drop wise. Beam balance was used to measure solid barium chloride salt to prepare its solution during test for barium ion (Ba^{2+}). In the similar fashion, they counted (measured) 2-3 drops of reagents like Methyl orange, Bromo methyl blue and universal indicators to observe their colors in Acid-Base solutions.

Application

After I revised them the underlying theory, they were able to check for the absence or presence of ions in unknown ion solutions provided for them in lab. For instance the following drawing was taken from the one they exercised to apply.

Table 11 Record from students' science concept application

ExpNo		Result for Known ion test	Result for Unknown ion test	**Conclusion drawn** for unknown ion solution
1	Red litmus	turns Blue	No change	Must be neutral
	Blue litmus	no change	No change	
2	Conc.HCl	Evolve bubbles	Evolve bubbles	Probably contain either HCO_3^- or CO_3^{2-} ions

This implies that students were able to set theories and try to prove/disprove its reality using experimentation methods they discussed in laboratory. Through this they arrived at their own conclusion for the unknown species in the given sample. This was one of the areas where the students developed connection between their science concepts and process skills ability widely.

Compare/contrast

Comparison of properties between known and unknown ion solution was made using the same reagents on each of these samples which led them to arrive at the final conclusion. Hence, they compared and contrast the similarity and difference between the two solutions in property for decision making when known and unknown ion solution was supplied for them in order to test for.

Data record skills

The students used tables, drawing of the experimental set up apparatus, writing symbols and formulas, equations, and personal abbreviations to register their findings and observations from experimental activities in lab.

Safety rules

All students came to lab class with safety guides and lab manuals in hands. They read the procedures, precautions, required theories and objectives of the practical lessons before coming to class as seen from triangulation at every starting phase of practical activity. Available safety materials were worn. In addition, students washed beakers, eye droppers and test tubes all the time before and after each practical work. Apparatus were seen being labeled before chemicals (samples) taken. Work tables cleaned using sponge and apparatus taken to their shelves (original places) at the end of the class. Solid and liquid wastes were kept separately in line with the instruction given on the safety guide.

Writing Report / scientific writing

Students were able to report their work following the scientific procedure which they have learned on Chem 103 courses and which was included on their lab manual. They recorded data appropriately. It was explained qualitatively which was set under recommendation on their report. Majority of them were able to relate skills gained with the objects of the lesson because of doing the experiments. When analyzing the data, the underlying theories were used to create connections between the theoretical and practical concepts they learned.

2. Experiences gained

As it was stated under analysis, the data triangulation from Test, Observation and Questionnaire implies that encouragingly students self confidence (ability) and practical work experience on each and every activity implemented showed a great improvement.

RECOMMENDATIONS

It is known that science needs critical thinking, observation, analysis, drawing conclusion, imagination and modeling. Planning and implementation of the following will help our students to exercise these processes and lay better ground to develop background of good science skill experience.

1. Plan "Starting-Ongoing-Ending" Approach

Incorporating pre-lab, during the practical work of lab and at the end of lab practice activities and focus points could help learning and it creates more opportunity to look at different angles on a single activity.

2. Encourage Cooperative Learning

Cooperative work between students, students & teacher and between teachers can boom students` practical work ability and experience. It also helps easy of teaching-learning process.

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Appendix A
Questionnaire
Pre-Intervention

S. No	**Focus Points**	**NAC**		**AC**		**%AC**
		1	**2**	**3**	**4**	
1	Taken the sample and reagents using dropper, Pipette, Burette Or Tilting the Beaker	1	12	6	3	37.5
2	Registered (recorded) what is seen from experiment as Text, Table, Drawings or your own abbreviation during the practical work.	3	6	8	9	70.8
3	Ppt formed, color changed or Both during the experiment.	1	6	9	8	70.8
4	The following properties: Concentration, Volume, Drops, Mass or Temperature of the sample have been measured during the experiment.	11	7	5	1	25
5	Any calculation of the results has been done during lab/ during report writing.	5	9	5	5	41.66
6	Graphs, tables, or others used to explain what observed from the experiment.	2	8	12	2	58.3
7	Working table and all apparatus cleaned before, at the end or both time of the experiment.	4	5	9	6	62.5
	Average					52.37

Post-Intervention

S. No	Focus Points	NAC		AC		%AC
		1	**2**	**3**	**4**	
1	Taken the sample and reagents using dropper, Pipette, Burette Or Tilting the Beaker	0	7	12	5	70.8
2	Registered (recorded) what is seen from experiment as Text, Table, Drawings or your own abbreviation during the practical work.	0	4	10	10	83.3
3	Ppt formed, color changed or Both during the experiment.	3	4	7	10	70.8
4	The following properties: Concentration, Volume, Drops, Mass or Temperature of the sample have been measured during the experiment.	4	7	12	1	54.16
5	Any calculation of the results has been done during lab/ during report writing.	4	7	9	4	54.16
6	Graphs, tables, or others used to explain what observed from the experiment.	2	3	13	5	75
7	Working table and all apparatus cleaned before, at the end or both time of the experiment.	0	4	6	14	83.3
	Average					70.21

Where NAC=Not Accepted, AC= Accepted the concepts mentioned in focus points

Appendix-B
Test

S.NO	ID.NO	Pre-Int	Post-Int
25.	NSR-AL/0118/05	14	15
26.	NSR-AL/0119/05	5	13
27.	NSR-AL/0122/05	1	12
28.	NSR-AL/0123/05	10	12
29.	NSR-AL/0130/05	14	15
30.	NSR-AL/0132/05	12	15
31.	NSR-AL/0135/05	7	11
32.	NSR-AL/0136/05	11	12
33.	NSR-AL/0138/05	11	10
34.	NSR-AL/0141/05	12	13
35.	NSR-AL/0150/05	15	11
36.	NSR-AL/0143/05	5	11
37.	NSR-AL/0128/05	14	13
38.	NSR-AL/0140/05	11	14
39.	NSR-AL/0147/05	5	11
40.	NSR-AL/0151/05	13	15
41.	NSR-AL/0137/05	10	13
42.	NSR-AL/0125/05	12	13
43.	NSR-AL/0121/05	8	12
44.	NSR-AL/0148/05	13	12
45.	NSR-AL/0117/05	9	11

46.	NSR-AL/0139/05	9	13
47.	NSR-AL/0134/05	11	14
48.	NSR-AL/0120/05	13	14
Average		10.21	12.67
Percent		68.06	84.44

Appendix-C

Observation/Assessment

S.NO	ID.NO	Pre-Int	Post-Int
49.	NSR-AL/0118/05	12	13
50.	NSR-AL/0119/05	9	13
51.	NSR-AL/0122/05	8	12
52.	NSR-AL/0123/05	11	14
53.	NSR-AL/0130/05	12	14
54.	NSR-AL/0132/05	11	11
55.	NSR-AL/0135/05	10	13
56.	NSR-AL/0136/05	11	11
57.	NSR-AL/0138/05	11	12
58.	NSR-AL/0141/05	11	11
59.	NSR-AL/0150/05	12	14
60.	NSR-AL/0143/05	9	13
61.	NSR-AL/0128/05	11	11
62.	NSR-AL/0140/05	10	8
63.	NSR-AL/0147/05	9	8
64.	NSR-AL/0151/05	11	9
65.	NSR-AL/0137/05	10	8
66.	NSR-AL/0125/05	11	9
67.	NSR-AL/0121/05	9	9
68.	NSR-AL/0148/05	11	10
69.	NSR-AL/0117/05	10	10
70.	NSR-AL/0139/05	10	10
71.	NSR-AL/0134/05	10	8
72.	NSR-AL/0120/05	11	10
Average		10.40	10.88
Percent		69.47	72.50

Int=Intervention

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