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).

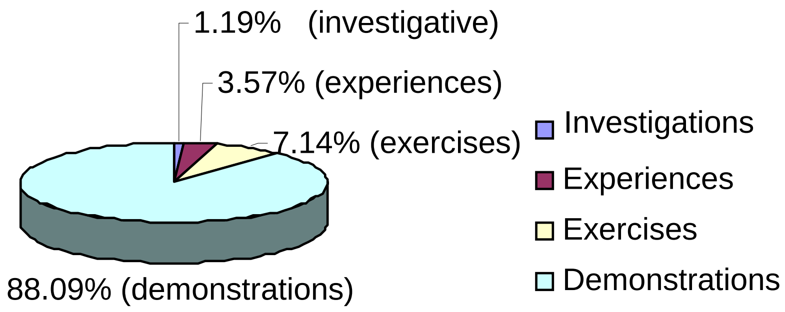
As shown in Table 3 above, 98.8% (83) of the laboratory work is devoted to the two lower levels, namely level 0 where the problem, the material needed, the procedures to follow, what type of data to collect are all given to the students who already know what the results will be or what to conclude and 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.

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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

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