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ACRONYM

ABC	Application in Biology/Chemistry
DLALR	Deficiency Level of the Availability of Laboratory Resource
EDFV	Estimation of Diameter of Field of Vision
FLE	Function of Laboratory Equipment
GPA	Grade Point Average
HEEE	Higher Education Entrance Examination
HM	Handling of Microscope
ILE	Identification of Laboratory Equipment
IULD	Insufficient Use of Laboratory Resource
LAI	Laboratory Task Analysis Instrument
M	Mounting
ML	Measuring Liquid
MW	Measuring Weight
SM	Setting of Microscope

CHAPTER ONE

1 INTRODUCTION

1.1 *Background of the Study*

Education is an instrument for national development which is used to develop human capital for effective functioning of the society. Biology education, in particular contributes a lot to human development in the areas of medicine, agriculture, environmental protection and food security. Moreover, it is important for students in their everyday life, in global competitiveness, resource utilization and environmental stewardship, in problem-solving skills, and understanding of the scientific methods (Kuddus, 2013). This can be realized when the quality of biology education is attained at better standards. Updating the standard and quality of biology education is essential to foster life-long learning of students leading them to global excellence in education.

According to Wambugu and Changeiywo (2008), students are facing many emerging issues, such as emergences of new drug resistant diseases, effects of genetic experimentation and engineering, ecological impact of modern technology, global warming, famine, poverty, health issues, population explosion, and other environmental and social issues. To overcome the challenges mentioned above, Turiman et al. (2011) suggested that students need to be equipped with the 21st century skills in science and technology education to ensure their competitiveness in the globalization era.

Students should be global citizens that recognize the critical need for the developing 21st century skills. Thus higher education graduates today, more than ever, need a basic understanding of science and technology in order to function effectively in an increasingly complex and technological society.

According to Chabalengula et al. (2009), science education comprises six domains: cognitive, psychomotor, affective, application, creativity and nature of science. The cognitive domain of science includes accepted scientific constructs, such as scientific laws, principles and theories. The psychomotor domain, often includes as performance or practical skills, includes science process skills, such as observation, manipulation of equipment/materials (assembling, measuring, and experimenting), classifying, communicating, inferring, predicting, identifying and controlling variables, interpreting data, and formulating hypotheses. The affective domain is primarily associated with explorations of human emotions, such as expression of personal feelings, decision making about personal values and about social and environmental issues. The application domain requires the determination of the extent to which students can transfer what they have learned to a new situation, especially in their own daily lives. The creativity domain is essential to science as it is used by scientists in generating problems and hypothesis and in the development of plans of action. The domain of the nature of science is related to characteristics of science, knowing the world around us through empirical methods and how scientists think and work in the science community.

The current philosophy of teaching science is an investigative, hands-on, minds-on, authentic learning experience (Gardiner, 1999). Practical activities are experiences in the learning –teaching process where students interact with materials to manipulate, observe and understand the natural world (Hofstein and Lunetta, 2004). The activities include laboratory practical work, field trip and practical attachment to various research sectors and industries.

Biology practical activities are experiences in the learning –teaching process where students interact with materials to manipulate, observe and understand the natural world (Hofstein and Mamlok-Naaman, 2007). Students develop their understanding of scientific concepts, science inquiry skills, and perceptions of science in the laboratory and laboratory activities include laboratory demonstrations, hands-on activities, and experimental investigations (Hofstein and Lunetta, 2004). Laboratory work is an active and interactive ways of teaching and learning method, which requires students to be involved in observing or manipulating real objects and materials, have a distinctive and central role for the development of students' understanding of scientific concepts, improving their cognitive skills, developing positive attitudes as well as stimulate students to greater efforts of achievement (Hunt, Koender and Gynnild, 2012). Laboratory practical experiences are central goals to biology education for the achievement of scientific proficiency. Emphasis should be given for the need and importance of laboratory practical skills in the undergraduate biology program of Ethiopian universities and biology should be kept in pace with our rapidly developing and understanding of the science and enthuse a new generation of knowledgeable young biologists.

The laboratory work should successfully be used and effective in getting students to do what is intended to promote conceptual change (Abraham and Millar, 2008). The effectiveness of laboratory work is useful to consider the process of developing and evaluating a laboratory task. Among the many variables to be considered are learning objectives, the nature of the instructions provided by the teachers and the laboratory guide , materials and equipment available for use in the laboratory investigation; the nature of the activities and the student–student and teacher–student interactions during the laboratory work; the students' and teachers' perceptions on assessment, students' laboratory reports, teachers' preparation, attitudes, knowledge, and behaviors (Lunetta, Hofstein and Clough, 2007).

To accomplish the objectives of science teaching, the laboratory manuals should provide the science process skills. The national science education standards (National

Committee on Science Education Standards and Assessment, 1993) recommend that laboratory activities should be written in a manner so that students will use the following categories of skills: (a) formulate useable questions, (b) plan experiments, (c) conduct systematic observations, (d) interpret and analyze data, (e) draw conclusions, (f) communicate, and (g) coordinate and implement a full investigation. Moni et al.(2007) proposed that students would learn these skills more effectively if they are individually assessed on core laboratory manipulative skills and that these skills should be assessed from their first-year of degree program.

Bone and Reid (2011) reported that students who completed biology at the senior high school-level did perform better than those who had not. Yet, there is little evidence on this issue. Hence, it is important to examine if there is correlation between students prior back ground in biology laboratory at secondary and preparatory schools and their biology laboratory skill performance test results. Moreover, there is also a debate on that scientific process skill acquisition varies among sexes. Ochonogor (2011) showed that there is a significant difference in performance level among biology education for undergraduates and between male and female biology education students. He claims that female students are more in biology education as a course and also perform significantly better than the males. Practical laboratory test may be administered individually or in groups. However, Jack (2013) stated that sex does not influence students' acquisition of science process skills.

This study, therefore, assesses the level of competencies of undergraduate biology students, identifies the area of deficiency in undergraduate biology laboratory work of Ethiopian universities by evaluating the curriculum, the assessment techniques of the laboratory work, and the extent of the objectives attainment.

1.2 *Statement of the Problem*

Developing countries, such as Ethiopia need skilled man power to expand educational opportunities by creating access and encouraging innovation and creativity. There is a need for the provision of affordable education services along with up- to- date learning resources without compromising quality and standard.

According to Federal Democratic Republic of Ethiopia (1994, p.7), the objectives of education in Ethiopia are to develop the physical, mental and problem solving capacity of individuals; to cultivate the cognitive, creative, productive and appreciative skills of citizens by appropriately relating education to environmental and societal needs; and to provide education that can produce citizens who have developed attitudes and skills to use and tend private and public properties appropriately. Accordingly, the Ethiopian Harmonized Curriculum for BSc Degree Program in biology(2009) is aimed to enable students acquire practical and technical skills required for utilizing biological tools; to train and provide students who can design and apply the principles of biology; and to identify and solve societal problems related to environment, agriculture, health, industry and teaching. To meet these objectives, the Ethiopian government is working to re-align its higher education system so that it can contribute more directly to its Growth and Transformational Policy and Poverty Reduction. Moreover, in the country the annual intake capacity of degree students has increased from around three thousand in 1994 to over thirty one thousand in 2004 (Yizengaw, 2005) and currently over one hundred and three thousands (National Agency for Examination, 2013). However, the success of education cannot only be measured in terms of how many students are being enrolled and how many students are graduated in the universities but the quality issue is the primary thing that should be addressed.

To attain the country’s Growth and Transformational Policy goals, seventy percent of higher education enrolment has been dedicated to science and technology education (Rayner and Ashcroft, 2011). The government is expanding the number and admission capacity of universities in the higher education sector but still low quality resource inputs are provided to universities (Yizengaw, 2005). Undergraduate biology students need to develop biology skills that will help them in their future life; enable them to solve day- to-day problems and think critically. However, employers and instructors complain that the majority of biology undergraduate students do not have basic laboratory manipulative skills (Abebe, 2013). Therefore, there is need to identify the factors responsible for the present state of affairs on the acquisition of biology practical skills at the undergraduate level in Ethiopia. There is currently no documented evidence that shows the extent of laboratory manipulation skills acquired by biology undergraduate students in Ethiopian universities.

The laboratories should be more efficient in accomplishing the objectives of teaching- learning science than other models of instruction because laboratory work is both time consuming and expensive compared with other models (Sabri and Emuas, 1999). A study conducted by Aladejama and Aderibigbe (2007) showed that the student’s academic performance is positively correlated with the science laboratory environments. Other studies have found that the less availability, misallocation and the deficiency in the use of science laboratory items lead to wastage of resources and lower academic achievement (Dahar and Faize, 2011). Similarly, a study conducted by Olufunke (2012) to determine the available physics laboratory equipment for the teaching and learning of physics in senior secondary schools in Nigeria as well as the extent of utilizing the available equipment showed that the optimal utilization of physics laboratory equipment is effective in the teaching of physics. They concluded that science laboratory with adequate equipment is a critical variable in determining the quality of output from senior secondary school physics.

Most of the higher education biology laboratory equipment are very expensive to be purchased. If this biology laboratory equipment is not efficiently utilized, it would be a big economic loss to the country, especially for the developing countries, like Ethiopia. Thus, the biology laboratory work and the actual practices of laboratory work in universities require some examination so that biology laboratory activities could be better designed and implemented, and be able to fulfill their objectives. However, no study has been conducted so far on the implementation of the intended practical activities and on the attainment of the intended objectives. Therefore, this study also has investigated whether there is relationship between the availability of laboratory materials and students competency or not.

The assessment of students' manipulation skills is important in that it provides students with the opportunity to demonstrate their manipulation skills, and understanding of processes and concepts through practically doing laboratory activities but it is often neglected by instructors in many Ethiopian universities because the instructors themselves do not have the necessary practical skills to organize, carry out and evaluate and investigate science activities (Bekalo and Welford, 1999; Chabalengula, et al., 2009). One of the major problems in science education is the lack of effective and efficient assessment techniques of the students' learning in the laboratory (Ottander and Grelsson 2006). Of the various techniques of assessing students' laboratory work, the most common laboratory evaluation techniques in universities are laboratory report and written examination (the act) during the lab, but not how well the students are capable of actually doing (performing) in biology laboratory based on their practical laboratory work (Slater and Ryan, 1993; Hunt et al., 2012). The existing evidence, however, is based largely on the assessment techniques but not on students' competency level.

The science laboratory tasks are practical activities important in the construction of scientific knowledge, especially biological knowledge, at university levels in Ethiopia. The tasks should be included in the laboratory manuals. However, no analysis has been done so far on the biology laboratory manuals to determine the presence of such activities. A study conducted by National Educational Assessment and Examinations Agency, FDRE (2013) to assess grade 8 pupils' academic achievement with respect to curriculum goals in science subjects showed that the composite average performance for Biology was42.10%. However, no study has conducted on the assessment of laboratory performance skills of the undergraduate students. Therefore, there is need to investigate and fill in the existing gap regarding the existence and level of the laboratory activities and also to identify the extent of science process skills inherent in Ethiopian universities for the undergraduate biology laboratory manuals.

A few studies have been carried out to examine the relationship between students' high school background and university course achievement. But there is still a debate among researchers. However, none of the studies have examined theses variables to determine the relationship between undergraduate biology students' prior secondary and college preparatory school biology laboratory back ground and their undergraduate laboratory skill performance. Hence, it is important to establish if there is correlation between prior back ground in biology laboratory at secondary and preparatory schools and the biology laboratory skill performance test scores.

This study, therefore, investigates the relationship existed between students' biology laboratory skill performance and their course achievement in undergraduate biology program. It also examines the relationship between high school laboratory experience and their undergraduate biology laboratory practical skill performance at undergraduate level.

1.3 *Purpose of the Study*

The aim of this study was to assess the undergraduate biology practical instructions in some Ethiopian universities with a view to determining whether the intended objectives, as stated in the national curriculum for undergraduate biology in Ethiopia were being attained and to identify the factors that affect the acquisition of biology laboratory skill by undergraduate students using skill performance rubrics and questionnaires. It was also aimed at evaluating the extent to which under graduate biology laboratory guides (manuals) promote the basic and integrated science process skills that are involved in scientific inquiry using seven levels of Laboratory Task Analysis Instrument (LAI).

1.4 *Research Questions*

1.4.1 Central research question.

How is the level of Ethiopian biology undergraduate students' competence in practical laboratory skills impact to their performance?

1.4.2 Sub questions.

Under the above major research a question, the study has also answered the following sub-questions:

1. What is the type and number of practical activities of undergraduate biology laboratory activities conducting in Ethiopian universities, compared with the number and type of laboratory exercises recommended in the curriculum?
2. To what extent do biology students acquire the competencies and skills prescribed in the graduate profile?

3. What is the relationship between the availability/unavailability of laboratory equipment and the students' laboratory skill performance?
4. How does teaching experience of instructors affect the attitude to conduct and organize biology laboratory practical activities?
5. How do instructors assess the biology practical activities?
6. What is the relationship between students' biology laboratory skill performance and their course achievement (GPA)?
7. What are the prominent science process skills included in the undergraduate biology laboratory of Ethiopian universities?

1.5 *Significance of the Study*

Laboratory practical activities have a pivotal role in the attainment of the goals in biology education. This study would possibly give insight to determine what was intended in the curriculum and what has been done with regard to biology laboratory practical instruction. Thus, the results of this study would create opportunities for universities and other concerned bodies to get information so as to solve problems that hinder the acquisition of practical skill. The findings of this study would also provide the universities with the opportunities to use time- and cost-effective laboratory teaching by assessing their students' laboratory performance skills and take intervention that would enable the students to be productive and contribute towards global excellence in their practical skills. Moreover, the study serves as a stepping stone for researchers who want to carry out further investigation on the biology curriculum implementation in the Ethiopian universities contexts.

1.6 *Limitation of the Study*

This study was limited to third year biology undergraduate students who have enrolled only in three of the thirty one governmental universities in Ethiopia because of time and financial constraints. Moreover, among the many biology practical activities, the assessment of Laboratory Practical Skill Performance Test focuses only in the three basic and minimum biology laboratory skills.

1.7 *Definition of Key Terms*

Biology practical activities: are experiences in the learning –teaching process where students interact with materials to manipulate, observe and understand the natural world (Hofstein and Mamlok-Naaman, 2007).

Competencies: acquired skills, attitudes and knowledge

Laboratory exercise: an individual experiment or observation set up in a laboratory manual to investigate a particular problem or hypothesis (Peters, 2006).

Laboratory manuals: handbook or worksheet that should provide step-by-step detailed instructions (Hofstein and Lunetta, 2004).

Laboratory performance assessment - a type of assessment activity in science in which students apply or demonstrate their scientific thinking skills (Craw, 2009).

Laboratory: the setting where introductory college biology students actively engage in simulated scientific practices (Peters, 2006).

Performance assessments: in the science laboratory, students are graded on the performance of manipulating variables, using scientific apparatus, identifying hypotheses, making measurements and calculations, organizing and managing data, and the communication of results (Slater and Ryan, 1993).

Performance: the accomplishment of a given task measured against preset known standards of accuracy, completeness and speed (Harris et al., 2007).

Science process skills: the cognitive and psychomotor skills scientists use to construct knowledge in order to solve problems and formulate results (Özgelen, 2012).

Teaching experience: instructors' years of teaching experience (Richardson, 2008)

CHAPTER TWO

2 LITERATURE REVIEW

2.1 *Introduction*

This chapter provides a review of literature related to the role of laboratory work in biology education, the assessment methods of laboratory work and various learning environment for the effectiveness of biology practical activities in undergraduate biology program.. It also investigates the relationship between the students' theory and practical performance in undergraduate biology education of Ethiopian universities.

2.2 *Definition of Laboratory Work*

Tamir, Doran and Kojima (1992) defined laboratory exercise as practical skills. According to Hofstein (2004), a practical activity in science education is an activity used to engage students in investigation, discoveries, inquiries and problem solving activities and is the center of science teaching and learning. Biology practical classes take place in a wide range of courses. Practical classes are some sorts of learning exercises in a laboratory, but this view can be extended to include fieldwork, museum or gallery visits, placement and work. Experiential learning theory (Kolb, 1984) suggests that students learn more effectively by 'doing' than by 'listening' (active rather than passive learning) and this is a major strength of learning in the field where students are involved in project planning, data collection and analysis. Therefore, practical classes form an essential part of the learning experience for biology students, cultivating both their subject-specific and generic skills that will be of value throughout their university lives and future careers. Genovese (2004) quantified the efficacy of the different learning styles as "students remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, and 90% of what they say and do". According to Yadav and Mishra (2013), no course in biology can be considered as complete without including some practical work in it. Biology is a scientific field of study should be learnt through experimental method.

Millar, Tiberghien and Marechal (2002) classified practical tasks into four groups. These are illustration (of theory), exercise (to practice standard procedures), experiences (to give students a 'feel' to phenomena) and investigation (to allow students to experience scientific enquiry).

2.3 *The Role of Laboratory Work*

Several studies have been conducted about the role of laboratory work in science (Hofstein, 2004; Hofstein and Lunetta, 2004). Laboratory practical work uses as primary means of instruction in science **(**Blosser,1990)**;** gives opportunities for students to manipulate equipment and materials (Tobin,1990) helps students to build confidence in their problem-solving abilities (Sundberg and Moncada, 1994; Tarhana and Sesen, 2010); maximizes their conceptual development (Domin, 2007); and develops their academic performance (Aladejama and Aderibigbe, 2007). Moreover, laboratory practical activity in science values learning new skills and using new equipment, gives opportunity for students social interaction, illustrates materials given in lectures and develops high interest; and stimulate students to greater efforts of achievement(Collis et al.,2008; Hunt et al., 2012). Lee et al. (2012) conducted a study to examine learning outcomes by measuring students' academic performance and their skill in writing research proposals. Results showed that students enrolled in both lecture and laboratory courses performed better in classification of species, research study design, proposals writing and in essay writing as compared to students taking lectures only.

However, few studies have claimed several issues that hinder the implementation of the laboratory work. For example, Trapani and Clarke (2012) stated that the laboratory activities largely focus on illustrating concept and the delivery of information because of several factors. Among the factors are equipment and other resource constraints, large groups size, lack of sustained and repeated exposure to given practical skills and experimental techniques, poor organizational and time management, and variations in instructors skills in teaching the laboratory teaching and learning.

To equip students with practical skills important in their future careers, laboratories should be efficiently used by teachers and students, and teachers themselves should possess these skills. Biology laboratories have very important role in the education system for biology students to bring rapid and significant advancement to the society. Hence, consideration in the process of developing and evaluating a laboratory work task is important (Millar et al., 2002).

2.4 *Assessment of Student Laboratory Work*

Assessment is an integral component of the education process; it supports learning by providing learners with the opportunity to demonstrate acquired skills and knowledge, while determining their professional, vocational and academic achievements (Ashford-Rowe, Herrington and Brown, 2014). Practical work is one of the ways of assessing the objectives of teaching biology in which an opportunity is provided for testing application of scientific procedures, manipulative abilities as well as scientific skills (Ongowo and Indoshi, 2013).

The assessment of laboratory courses should be able to test student competence over a wide range of practical skills (Bekalo and Welford, 1999). Hofstein and Lunetta (2004) stated that assessments of students' performance and understanding associated with the science laboratory should be an integral part of the laboratory work of teachers and students. They argued that assessment tools should examine the students' inquiry skills, their perceptions of scientific inquiry, and related scientific concepts and applications identified as important learning outcomes for the investigation or the series of investigations. An important part of being a modern biologist is the ability to perform certain technical or manual skills in biology, such as running gels, pipetting, recording, performing tissue culture and other skills. However, biology instructors assess mostly knowledge by grading exams, quizzes, papers and laboratory reports (Fitch, 2007). There are two general forms of tests: 'pen-and paper' tests and 'practical' or 'laboratory performance' tests. Research has shown weak correlations between test scores from practical tests and pen-and-paper tests. For example, Hammann et al. (20008), investigated whether scores from multiple-choice tests correlate with student performance in a practical test on seed germination. In addition, Urda and Ramocki (2015) showed that there is no relationship between student preferences in assessment type and their performance in the respective assessments. The results revealed that there is a big difference between multiple-choice items and performance test scores.

It was noted that the objectives of science practical work depend a lot on the mode of assessment of laboratory work adopted by the instructors and examination bodies, and the mode of assessment directly influences teachers' teaching methods, students' learning styles and attitudes towards practical activities (Giddings and Fraser, 1988, in Akinbobola and Afolabi, 2010).

Hunt et al. (2012) stated that the aim of teaching practical laboratory skills can be best achieved by assessing those skills in the laboratory rather than assessing written laboratory reports or answers to examination questions. Assessment of practical work encourage students to develop useful physical, technical and experimental skills and it also encourages other generic skills that are valued by employers and useful for students' real life authentic task and lifelong learning (Harris et al.,2007).

The implementation of more authentic forms of assessment becomes important for higher education (Ashford-Rowe, et al., 2014). But instructors are less likely to use more open-ended, authentic forms of laboratory performance assessments due to their background, experience, or subject matter taught. The knowledge and skill of students in biology should not be measured only by paper and pencil examination items, but also in part by how well the students are capable of actually performing biology practical activities. This can be made by examining their competency in the skill sets.

The student's skills can be measured based on authentic tasks, such as activities, exercises, or problems that require students to show what they can do. One of the most widely used of these is called performance assessment. The features of performance assessment are the use of a graded and authentic task. An authentic task is one in which students are required to address problems grounded in real-life contexts. With performance assessments in the science laboratory, students are graded on the performance of manipulating variables, using scientific apparatus, identifying hypotheses, making measurements and calculations, organizing and managing data, and the communication of results (Slater and Ryan, 1993). Such tasks are typically complex, somewhat ill-defined, engaging problems that require students to apply, synthesize, and evaluate various problem solving approaches (Shavelson, Baxter, and Pine, 1991). However, performance assessment requires more time to administer than other forms of assessment and resource intensive (Harris et al., 2007). Heyborne, Clarke, and Perrett (2011) studied that the replacement of free-response practical examination questions with multiple-choice practical-examination questions have profound implications with regard to student performance and learning in the laboratory portion of an introductory college-level biology course. Hammann et al.(2008), demonstrated that performance assessment is more time-consuming to administer and to code but is more appropriate than multiple-choice tests in providing the information necessary for planning new steps in the learning process which allow for a more detailed description of students' achievement and provides insights into qualitatively different strategies of planning experiments and analyzing data .

Whelan et al. (2010) reported that students' employability skills is the current concerns and have become the subject of considerable attention by governments around the world. Traditional modes of assessment failed to address adequately the development of practical laboratory skills considered to be useful by employers (Hunt et al.,2012).The practical assessment of students' performance of relevant laboratory skills has the potential to influence graduate employability as many graduates find work in biology related fields or biology laboratories (Hunt et al.,2012). According to Hughes (2013), base standards should be established at a program, course or task level within and across countries for the employability of the graduates that could satisfy the demand of the employers.

2.4.1 Performance and pperformance aassessment.

Performance is defined as the accomplishment of a given task measured against preset known standards of accuracy, completeness and speed. The particular skills and competencies developed through practical learning in the biological sciences are as varied as the courses themselves and have also common skills (Harris, et al., 2007). Recently, science educators have shown increased interest in developing practical skills and competency- based approach, and assess specific core laboratory skills. Craw (2009) defined laboratory performance assessment as a type of assessment activity in science in which students apply or demonstrate their scientific thinking skills.

Several studies have also been conducted on how to assess the competencies. For example, Craw (2009) stated that laboratory performance assessments provided teachers with valuable information to adjust instruction, inform curricular decisions, and as a basis for professional development. Implementing performance assessment as a teaching methodology is used to improve inquiry-based science education, promote the development of 21st century skills and competencies, involve students in the assessment process, provide teachers with valuable information to inform instruction, and as a tool for professional development. Performance tasks involve students demonstrating their understanding through actual manipulation of equipment and materials in the laboratory. However, several authors have indicated that the actual doing of the laboratory activities is rarely assessed (Tobin et al., 1990; Moni et al., 2007).The assessment of practical skills and competencies is of two broad types: direct assessment, where either the demonstration of the skills themselves are the object of assessment; and indirect assessment, where a students' level of a practical skill has a bearing on a related, assessed activity (Harris, et al., 2007).

Several studies have been conducted how to assess the competence. For example, Slater and Ryan (1993) have developed six performance task evaluation for an introductory physics laboratory evaluation with four discrete competency levels (i.e. no evidence, approaches goal, meets goal and exceeds goal). They stated that the instructor observes and evaluates students' competency levels with respect to the specific skills laboratory exercises which are designed to teach.

Shavelson et al. (1991), developed alternative performance assessment instrument for fifth and sixth grade students assisted by computer simulation. Both researchers mentioned above, agreed that although the hands-on assessment is desirable, it is expensive and time consuming to administer. Moreover, Moni et al. (2007) have designed and implemented a strategy to assess individually 5 core laboratory skills of students in first-year laboratories for the course Human Biology. They designed a form for tutors to record the skill level of each student. Three levels of skill attainment were defined: not proficient, toward proficiency, and proficient. However, the levels used to evaluate the skills were more subjective like those used by Slater and Ryan (1993).

Craw (2009) studied the performance assessment practices of high school science teachers. The results revealed that teachers were less likely to use more open-ended, authentic forms of laboratory performance assessments. There was variability in teacher implementation of performance assessment possibly due to teachers' background, experience, or subject matter taught.

Hunt et al. (2012) have done an action research project to assess laboratory skills in a molecular biology course by replacing a single examination with direct observation of student participation and learning over a prolonged period of weekly laboratory sessions. They argued that practical laboratory skills should be assessed in the laboratory by observing what the students are actually performing rather than assessing written laboratory reports or answers to examination questions. A study conducted by Cushing (2002) to compare the performance of thirty four high school students on laboratory assessments of biology showed that there was a greater diversity of knowledge and skill categories. Moreover, Falicoff, Castiñeiras and Odetti (2014), conducted a study to assess the science competency of first year university students enrolling in the school of biochemistry and biological sciences and examine the effects of these courses on their competencies of chemistry proficiency. The results indicated that first-year students started with a low performance level for all the sub-competencies assessed and performance levels on using scientific evidence decreased.

2.5 *Inquiry and Science Process Skills*

Inquiry can be an effective teaching approach to support students' learning for long-term retention. Promoting inquiry in the laboratory empowers the students to take these trained skills and conduct further investigations. Hence, laboratory activities provide excellent opportunities to incorporate inquiry in to the curriculum (Tweedy and Hoese, 2005). Inquiry-based biology laboratory instruction improves scientific skills and critical thinking (Tessier, 2010).

Özgelen (2012) defined science process skills as they are the thinking skills scientists use to construct knowledge in order to solve problems and formulate results. According to Jack (2013), science process skills are cognitive and psychomotor skills employed in problem solving process and in the acquisition of science process skills which are the basis for scientific inquiry, development of intellectual skills and attitudes that are needed to learn concepts. These skills can be acquired and developed through science practical activities and retained when cognitive knowledge has been forgotten. Tarrant (2005) stated that students who are scientifically literate should possess skills such as the ability to think critically, use scientific reasoning, and interpret various types of data, use facts and logic to solve problems, formulate arguments, and understand the world in which they live. These skills help students to be global citizens and practice environmental stewardships. The biology practical skills are science process skills that are taught as part of the biology curriculum and these skills can be acquired and developed through activities involved in the biology practical sessions (Ongowo and Indoshi, 2013). A study conducted by Blanchard et al. (2010) revealed that students who participate in an inquiry-based laboratory unit showed significantly higher post test scores, long-term retention, and tended to have better outcomes than students who learned through traditional methods. A study conducted by Haskins (2000) to quantitatively determine whether the material found for application in biology/chemistry promotes science inquiry through the inclusion of science process skills, and to quantitatively determine the type and character of laboratory activities showed that all laboratory activities provided very more in basic science process skills. Ergül, et al. (2011), conducted a study to determine Turkish elementary school students' level of success on science process skills and science attitudes and if there were statistically significant differences in their success degree and science attitudes depending to their grade level and teaching method. Their result showed that use of inquiry based teaching methods significantly enhances students' science process skills and attitudes. Ongowo and Indoshi (2013), conducted a study to determine the science process skills included in the Kenya Certificate of Secondary Education biology practical examinations for a period of 10 years (2002- 2012). The results revealed a high percentage of basic science process skills at 73.73% compared to the integrated science process skills at 26.27%.

The American Association for the Advancement of Science (AAAS, 1993), has categorized science process skills into Basic Science Process Skills, and Integrated Science Process Skills. Basic science process skills consist of observing, using space or time relationships, inferring, measuring, communicating, classifying, and predicting, where as integrated science process skills include controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, formulating models, and presenting information. According to Sheeba (2013), the science process skills enable the students to apply scientific concepts, procedures and attitudes to their wider life. Therefore, these skills affect the personal, social, and global lives of individuals.

There are different approaches of classifications of laboratory tasks. As shown in Table 1 below, Banchi and Bell (2008) have classified the science education of inquiry-based learning in to four levels, namely confirmation inquiry, structured inquiry, guided inquiry and open inquiry. The levels focus on how much information (e.g., guiding question, procedure, and expected results) is provided to students, and how much guidance is provided by the teacher. At the first level (confirmation inquiry), students are provided with the question and procedure (method), and the results are known in advance. In the second level (structured inquiry), the question and procedure are still provided by the teacher; and students are expected to generate explanation supported by the evidence they have collected. In the third level (guided inquiry), the teacher provides students with only the research question, and then the students design the procedure (method) to test their question and the resulting explanations. In the fourth and highest level of inquiry (open inquiry), students generate their own questions, plan their investigation, collect and organize their data, and communicate their results. This level requires the most scientific reasoning and greatest cognitive demand from students. A study conducted by Katchevich, Hofstein and Mamlok-Naaman (2013) showed that inquiry-type of experiments have the potential to serve as an effective platform for formulating arguments, owing to the features of the learning environment in general and an open inquiry experiment focus on the hypothesis-building stage, analysis of the results, and drawing appropriate conclusions in particular.

Table 1 : The four levels of inquiry and the information given to the students in each one (Banchi and Bell, 2008)

Inquiry level	Description	Question	Procedure	Solution
1.Confirmation Inquiry	Students confirm a principle through an activity when the results are known in advance.	√	√	√
2.Structured Inquiry	Students investigate a teacher-presented question through a prescribed procedure.	√	√	
3.Guided Inquiry	Students investigate a teacher-presented question using student designed/ selected procedures.	√		
4.Open Inquiry	Students investigate questions that are student formulated through student designed/selected procedures.			

2.6 *Laboratory Manuals*

Literature showed that there are various factors that influence the acquisition of cognitive skills, such as science process skills (Domin, 1999; Pešaković, Flogie and Aberšek, 2014). Among the various factors, science curriculum is the one that affects the students' practical work in the acquisition of science process skills. Laboratory manual is the part of science curriculum. Kuddus (2013) stated that the biology curriculum should include integrated core concepts and competencies; introduce the scientific process to students early, and integrate it into all undergraduate biology courses; define learning goals around the core concepts and assess students on these goals; make connections between abstract concepts to real-life contexts, develop life-long learning competencies; discuss fewer concepts in greater depth; stimulate curiosity to natural world ; and show the passion as a scientist and an educator. Students' laboratory guide is one of the curricular materials.

According to Hofstein and Lunetta (2004), the handbook or worksheet is considered as the laboratory guide. It plays a central role in shaping the students' behaviors, learning, and in defining goals and procedures. Laboratory manuals are important components of science instruction and should be evaluated for their use of inquiry. Germann, Haskins and Auls (1996) stated that the laboratory manuals should provide students with step-by-step detailed instructions and ask them to manipulate materials, make observations and measurements, record results, make qualitative and quantitative relationships, draw conclusion, make inferences and generalizations, and communicate and interpret the results. Sabri and Emuas (1999) stated that teaching science through laboratories needs to be constantly evaluated using one or more of the following methods:

1. Comparison of the academic achievement of students who are taught through the laboratory method compared with the achievement of students taught through other models;
2. The extent to which laboratory instruction, experiments, and textbook are congruent with the expected objectives of teaching sciences should be investigated;
3. Investigating the efficacy of science laboratories by examining particular aspects and conditions of laboratory instruction methods;
4. The management of student groupings and tasks in laboratory experiments should be examined for their effect on students' performance.

Several studies indicated that a process skill-based science curriculum can contribute positively towards the expected science learning outcomes. The laboratory manual reduces the amount of time necessary to complete a laboratory activity by providing an instructional pathway that does not require the utilization of higher –order thinking skills and has become an instrument that maximizes laboratory efficiency at the expense of fostering higher-order cognition (Domin,1999). The students' laboratory Manual plays a central role in shaping the students' behaviors and learning, and in defining goals and procedures (Hofstein and Lunetta, 2004). Laboratory manuals are important components of science instruction and should be evaluated for their use of inquiry. Sundberg and Moncada(1994) stated that manuals for implementing an investigative laboratory program in a classroom should contain awareness and purpose of investigation, an initial series of activities prepare students to investigate, formulate problems and investigatory procedures, to repeat and/or modify experiments and prepare written and/or oral reports. Manuals should also include much inquiry and they often engage students in the planning and designing of the activities, and they should also encourage students to apply the skills or techniques they have learned to new situations (Tweedy and Hoese, 2005). However, the task of creating a meaningful and relevant curriculum based on the necessary skills of the 21st century is not an easy one (Gauchet , 2011).

A few analyses of science laboratory manuals using the Laboratory Structure and Task Analysis Inventory (LAI) have been done. For example, Tamir and Lunetta (1978) have analyzed secondary high schools science laboratory manuals by 16-item Laboratory Structure and Task Analysis Inventory (LAI). They found that laboratory manuals foster students' manipulative skills, qualitative and quantitative relationships, and inferences to drawing conclusions, and communicating results in scientific investigations. The manuals, however, were lacking in inquiry skills such as designing experiments, formulating hypotheses, applying experimental techniques to new investigations, and reflecting on possible sources of errors.

Germann et al. (1996) studied seven high school biology laboratory manuals using a modified version of Tamir and Lunetta(1978) laboratory manual inventory. They concluded that most manuals did not provide opportunities for students to pose a question to be investigated, formulate a hypothesis to be tested, or predict experimental results; to design observations, measurements, and experimental procedures; to work according to their own design; or to formulate new questions or apply an experimental technique based on the investigation they performed.

Basey, Mendelow and Ramos (2000) investigated laboratory manuals at six randomly chosen community colleges in Colorado on how science inquiry and technology were incorporated into laboratory exercises. They showed that most of the exercises investigated a particular problem or hypothesis instead of allowing students to formulate a problem or to solve hypothesis.

Tweedy and Hoes (2005) did the most recent content analysis of 10 community college laboratory manuals analysis using a modification of Basey et al.(2000) inventories. They showed that the laboratory manuals failed in promoting higher-order cognition. They concluded that most manuals did not include much inquiry and often failed to engage students in the planning and designing of the activity, and they did not encourage students to apply what they learned in a broader context. Science educators recommended that major revisions of the science curriculum at various levels that courses emphasize science as a way of knowing and that they permit students to learn and experience scientific processes (Tweedy and Hoese, 2005). However, the past laboratory task inventories have done mainly on commercial college laboratory manuals, secondary high schools biology laboratory and other science disciplines manuals.

2.7 *Benefits of Laboratory Practical*

Many studies have been conducted about the importance of laboratory. Laboratory practical uses as primary means of instruction in science (Blosser, 1990); gives opportunities for students' to manipulate equipment and materials(Tobin, 1990); helps students to build confidence in their problem-solving abilities (Sundberg and Moncada, 1994); maximizes their conceptual development (Domin, 2007); develops their academic performances(Aladejama and Aderibigbe, 2007); values learning new skills and using new equipment; gives opportunity for students for social interaction; illustrates materials given in lectures and develops high interest (Collis et al.,2008); maximizes students' learning achievement, preventing misconceptions, develop positive attitude towards practical activities, and build self confidence(Tarhana and Sesen, 2010); and stimulates students to greater efforts of achievement (Hunt et al., 2012).

2.8 *Effectiveness of Laboratory Practical Activities*

The effectiveness of laboratory work is useful to consider in the process of developing and evaluating a laboratory work task (Millar et al., 2002). According to Royal Society of Biology (2010), high quality and appropriate practical work is central to effective learning in science and is a key factor in engaging, enthusing and inspiring students, thus stimulating lifelong interest in science. To equip students with practical skills important in their future careers; laboratories should be efficiently used by teachers and students, and teachers themselves should possess these skills. However, planning and carrying out practical work and assessment abilities in practical work were completely neglected in Ethiopia because the instructors themselves do not have the necessary practical skills to organize, carry out and evaluate investigative science activities (Bekalo and Welford, 1999). According to Millar et al. (2002), the teachers objectives (what the students are intended to learn from the task) and the task design (what the students are intended to do) are influenced by teachers views of science and learning, and by practical and institutional factors such as the resources available, the requirement of the curriculum, its mode of assessment, and so on. What the students actually do on the task and what they actually learn are influenced by the students' views of science and of learning, and by practical and institutional settings. Hofstein and Lunetta (2004) stated that the learning environment depends markedly on the nature of the activities conducted in the lab, the expectations of the teachers (and the students), and the nature of assessment, the materials, apparatus, resources, and physical setting, the collaboration and social interactions between students and teachers, and the nature of the inquiry that is pursued in the laboratory. An effective laboratory environment requires teachers' preparation and planning: students' conceptual pre-knowledge about the experiment; environment to use and reinforce such knowledge; usage of basic and higher-level science process skills; establishment of links between the subjects taught in classroom and laboratory and students' daily lives; and the maintenance of laboratory safety and safety awareness among students (Feyzioğlu, 2009). Lunetta et al. (2007) have listed numerous factors which should be considered to alleviate the associated problems in designing and implementing student-based laboratory experiments. These include learning objectives, instructions provided by the teachers and the laboratory guide, materials and equipment available, the nature of the activities, student–student and teacher–student interactions during the laboratory work, how performance and laboratory reports are to be assessed, the preparation, attitudes, knowledge, and behaviors of the teachers.

2.8.1 Learning Objectives.

Blosser(1990) stated that there are five groups of objectives that may be achieved through the use of the laboratory in science classes:

1.**Skills** : that include manipulative, inquiry, investigative, organizational, communicative

2.**Concepts** : for example, hypothesis, theoretical model, taxonomic category

3.**Cognitive abilities** : critical thinking, problem solving, application, analysis, synthesis

4.**Understanding the nature of science** : scientific enterprise, scientists and how they work, existence of a multiplicity of scientific methods, interrelationships between science and technology and among the various disciplines of science

5. **Attitudes:** for example, curiosity, interest, risk taking, objectivity, precision, confidence, perseverance, satisfaction, responsibility, consensus, collaboration, and liking science. Silvestrone (2005) stated that the quality of an examination increases when learning objectives are constructed in depth, clearly communicated, and applied throughout examination administration and grading.

2.8.2 Teachers' Experiences

There is debate about the causal relationship between teachers' experiences and students' achievement. Few studies indicate that the effect of teacher experience is not significant predictor on student performance (Haider and Hussain, 2014; Liu, Lee and Linn, 2010; Rice, 2010; Zhang, 2008). For example, Haider and Hussain (2014) showed that there is weak and negative weak relationship between the teacher factors, such as assessment interval, communication language, the distance of residence, and the teacher's personal characteristics (gender, age, academic and professional qualification, designation, experience, and in-service training), and student achievement in English, Chemistry and Mathematics. Similarly, Zhang (2008) stated that science teachers possessing of advanced degrees in science or education significantly and positively influenced student science achievement but years of teaching experience in science do not directly influence student science achievement.

However, the majority of studies indicate that the effect of teacher experience on student achievement is the greatest in the first few years (Clotfelter, Ladd and Vigdor, 2007; Dial, 2000; Lewis, 2006; Nunnery et al., 2009; Richardson, 2008). Lewis (2006) suggests that the extent to which teachers realize the potential for change depends on the types of support and professional development on curriculum and subject matter knowledge that they are offered. The teachers would have benefited from structured support and professional development which specifically addressed their personal and professional needs. These needs included guidance on how students find their way through the course, explanations of how particular activities were expected to achieve a particular purpose, guidance on how to manage these new practices and guidance on the potential needs of their students and ways in which they could support their students through the changes. Dial (2000) carried out a study to examine whether years of teaching experience and a teacher's degree level have an effect on overall achievement of students on the communication arts and mathematics sections of the Missouri Assessment Program. The results indicated teacher degree level alone had no effect on student achievement but years of experience, as well as the interaction between years of experience and degree level, had an effect on student achievement in both communication arts and mathematics. Clotfelter et al. (2007) concluded that a teacher's experience, test scores and regular licensure all have positive effects on student achievement. The Royal Society of Biology (2010) recommends that biology educators and technical support staff require training to be competent and confident to respond positively to the unpredictability of working with biological material and embrace the opportunities afforded by the breadth of the biosciences because they are vital contributors to the progress of science.

2.8.3 Teachers' Attitudes

Yıldız et al. (2006) studied that the attitudes of teachers towards the aims of science experiment can be affected by the availability of well- equipped laboratories, adequacy of laboratory equipment and years of teaching experience. However, they found that there was no difference in educational level and gender of teachers regarding to their attitudes towards the aim of science experiments. The teachers consider experiments to improve students' manipulative and cognitive skills and to develop sense of cooperative skills among students as the other important ones. Based on the findings, they concluded that the availability of well-equipped science laboratory affects teachers' attitudes towards aims of science experiments positively. According to Kamal and Muideen (2014), attitudes of teachers teaching chemistry in senior secondary schools have significant effect on the achievement of students in chemistry as one of the science subject.

2.8.4 Students' Attitudes

Science experiments develop students' observational skills (Yıldız et al., 2006). Menjo (2013) found that practical teaching techniques are perceived by science learners to be the most effective method but its utilization by teachers falls short of expectations. According to Wood (2004), Students' attitudes to practical work are influenced by the nature of undergraduate practical. In addition, Kampourakis and Tsaparlis (2003) reported that only a small proportion of the students found the practical activity relevant/useful to the solution of the problems, and these students had a much higher achievement than the rest of the students. Luketic and Dolan (2013) stated that students positive attitudes towards their laboratory work are influenced by the extent of their experiences in learning science and their perceptions are consistent amongst regular- and high-achieving students regardless of grade level.

2.9 *Students' Prior Background*

Higher education admissions officials typically use higher education entrance examination scores on university entrance to predict an applicant's probability of academic success in the universities. Moreover, employers use cumulate grade point average of the students as main selection criteria. Research studies show that undergraduate students' performance depend on many factors such as availability of learning resources, gender, age, socioeconomic status of the students (Hansen, 2000). Yet, there is little evidence on the relationship between students' theory and practical skill performance. A study conducted by Uwaifo (2012) showed that there is a statistically significant relationship between students' theory and practical performance scores. Aina (2014) reported that there are significant differences between students' performances in physics theory and practical; between female Physics theory and practical and also between male Physics theory and practical.

On the other hand research findings of showed that there is no relationship between students' achievement in theory and practical work scores (Achor, Kurumeh and Orokpo, 2012; Nawaz, Mahmood and Rana, 2004). Akanbi and Usman(2014) showed also that there is no relationship between physics student performance in micro-teaching and that of teaching practice.

Several studies have been carried out to examine the relationship between students' high school background and university course achievement. But there is still a debate among researchers. For example, Sadler and Tai (2001) have shown that high school physics course has a positive relationship with the grade earned in introductory college physics. Karemera, Reuben and Sillah (2003) showed that high school achievement is significantly correlated with college performance. A study conducted by Tai, Sadler, and Loehr (2005) to examine the link between high school chemistry pedagogical experiences and performance in introductory college chemistry showed that several high school pedagogical experiences are linked with varying levels of performance in college chemistry. Noble and Radunzel (2007) stated also that academically underprepared students have to spend more time and money taking remedial courses in college, earn lower grades and have lower retention rates. Geiser and Santelices (2007) have suggested that high school grades are the best predicators of academic performances. Adeyemi (2008) showed also that the junior secondary certificate examinations were a good predictor of performance at senior secondary certificate examination.

Sawyer (2008) found that high school course work and high school grades are related to achievement test (ACT) scores and encouraging students to take more rigorous college-preparatory courses help to earn higher grades in these courses. Bone and Reid (2011) reported that students who completed biology at the senior high school-level did perform better than those who had not. Clark (2011) showed that taking higher level science coursework in high school is also positively associated with final grade. Taking more semesters of higher level science coursework does not increase the likelihood of doing well in college chemistry, as there is no observable significant influence on final grade in chemistry. In addition, Amasuomo (2015) found that high admission points or good entry qualification used in selecting students for admission is most important predicator of students' academic performance at the post-secondary schools.

Loehr, Almarode , Tai, and Sadler (2012) studied the association between students' high school science education and mathematics experiences with introductory college biology the final course grade in introductory biology courses. The result showed that advanced high school science and mathematics coursework was positively associated with students' achievement in introductory college biology.

On the other hand, Wang (2009) claimed that there is little connection between mathematical educational knowledge and the educational background. Tai et al. (2005) stated that overemphasis on laboratory procedure in high school chemistry was associated with lower grade in college.

There is also a debate that practical skill test scores varies among sexes. For example, Ochonogor (2011) showed that there is a significant difference in performance level between male and female undergraduate biology students in that the female students perform significantly better than the males. However, Achor, Kurumeh, and Orokpo (2012) showed that male and female students' performance in a test of theoretical knowledge in Chemistry do not significantly predict their performance in Senior Secondary Certificate Chemistry theory examination. Jack (2013) argues also that sex does not influence students' acquisition of science process skills. However, none of the studies have examined theses variables to determine the relationship between undergraduate biology students' prior secondary and college preparatory school biology laboratory back ground and their undergraduate laboratory skill performance. Hence, it is important to establish if there is correlation between prior back ground in biology laboratory at secondary and preparatory schools and the biology laboratory skill performance test scores.

2.10 ***Fieldwork***

According to Scott et al. (2012), fieldwork is an important way of enhancing students' undergraduate learning, their life-long learning, and their career aspirations. They say that field work enables students to collect specimen by themselves, to construct a taxonomic list of organisms, to recall the structural detail of the organisms and to recall the detail of an ecological sampling methodology in the field better than in a classroom setting. Easton and Gilburn (2012) also showed that field courses can increase students' attainment and improve their cognitive learning in undergraduate biology courses. Wolfe and Martin (2013) also showed that field studies encourage students to ask questions about nature, formulate hypotheses for answering questions, evaluate conclusions and provide an opportunity for students to refine observation and inquiry skills beyond a set of laboratory exercises and classroom lectures.

Fieldwork is generally considered an essential aspect of teaching and learning about biology, at both school and university levels (Cotton and cotton, 2009). They noted that fieldwork is often claimed to improve students' learning, with suggested educational benefits including: better retention of acquired knowledge, enhanced motivation and higher-order learning and development of practical skills. In addition to the direct educational benefits, fieldwork has been reported to increase students' confidence and motivation (Boyle et al., 2007; Smith 2004). According to Nundy (1999), the combination of cognitive and affective domains in the field may provide enhanced learning outcomes, perhaps because learning experiences which are 'fun' appear to be more memorable in the longer term. Lee (1997) conducted a study to examine the impact of field trips on students' learning of specific biology topics. The result showed that students in the field trip groups had higher achievement as measured by quiz scores than those in the laboratory groups.

Rickinson et al. (2004) stated that fieldwork can have a positive impact on students' long-term memory due to the memorable nature of the fieldwork setting. Effective fieldwork and residential experience in particular can lead to individual growth and improvements in social skills. More importantly, there can be reinforcement between the affective and the cognitive domains, with each influencing the other and providing a bridge to higher order learning. El-Mowafy(2014) describes that assessment of fieldwork activities in the field involves specific preparation, instantaneous interaction, practice and the use of various tools such as equipment checks, checking safety policies and procedures prior to commencing fieldwork, professional field booking for recording of data and notes, field procedure, problem solving, interpretation of results, practical checks at different phases of the work including verification of final results and compliance with professional practice in all of the above. Tal, Alon and Morag (2014), described three variables that affect the quality of fieldwork the activity and its outcomes. These variables include: (1) the context—the school curriculum, the physical environment, the group's background and so forth; (2) the pedagogy and the agents who implement this pedagogy—teachers, field guides, the students and their interest, and (3) the content of the field trip.

According to Cotton and Cotton (2009), a number of barriers to fieldwork provision in higher education have been identified including: a dwindling number of lecturers with appropriate field skills, fear of litigation if something goes wrong, reluctance of students to spend time away from family or work commitments, increasing use of virtual methods as alternatives to fieldwork and the need for fieldwork to be accessible for students with disabilities. Over and above these specific barriers lie wider questions about the financial viability of fieldwork in a system of mass higher education, and about its educational benefits. Madden (2009) recommended that successful field studies require consideration of the content, context, and design of the intended field projects.

2.11 *Conceptual Frame work*

The model (Figure 1) shown below, demonstrates the assumption is that the competence of students is mainly influenced by the curriculum, methodology (instruction, instructors' experience, instructors' qualification etc) learning environments, such as availability of laboratory equipment, standard and assessment methods, students' prior high school background and understanding science process skills.

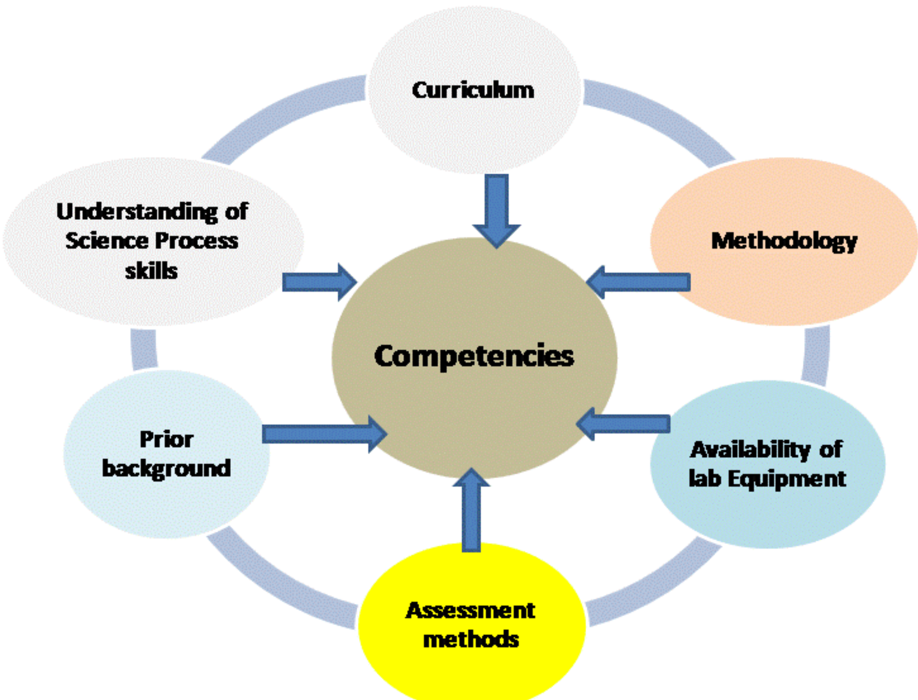

Figure 1: Conceptual model of the relationship of various factors with science laboratory skill competencies

2.12 *Summary*

This chapter discusses the review of related literature. The chapter starts with a brief explanation of the laboratory work and its role in science education in general and in biology education in particular. It also focuses on assessment of laboratory work, inquiry and science process skills, the role of laboratory manuals in biology laboratory instruction and the different approaches for the analysis of the laboratory manuals, effectiveness of laboratory practical activities, the relationship between students' laboratory skill performance and their prior background, instructors experiences and students attitudes. It discusses the development of a conceptual model and the design of the model.

It presents the task of the current research, which was to assess the level of the students' biology laboratory skill performance, identify the most predicting variable and investigate whether there is relationship or not between the availability of laboratory materials and students competency in Ethiopian universities.

CHAPTER THREE

3 METHODOLOGY

3.1 *Introduction*

This study addressed the evaluation of undergraduate biology practical activities in Ethiopian universities in order to draw possible recommendations for the higher institutions about how to improve the learning-teaching process of biology laboratory practical activities.

In this chapter the research design, population and sample of the research, instruments used in the study, validity and reliability of instruments, procedures for data collection, data analysis methods and discussion of ethical issues are provided.

3.2 *Research Design*

A descriptive sequential mixed method design was used and it involved collecting quantitative data first and then explaining the quantitative results with in-depth qualitative data. In the first quantitative phase of the study, data were collected using questionnaires from the sample of third year biology students in three universities to test whether students' laboratory practical skills with Deficiency Level of the Availability of Laboratory Resource(DLALR), Insufficient Use of Laboratory Resources(IULR), instructors' experiences, instructors' qualifications, students' background, students' attitudes, the organization of the laboratory, and the number of experiments in each course, presence of laboratory manual for each activities, size of group (independent variable) relate to the students' laboratory practical skill performance score (dependent variable).

The second, qualitative phase was conducted as a follow up to the quantitative variable results to explain the quantitative results. In this descriptive follow up, the plan was to evaluate the undergraduate biology students in some Ethiopian universities based on laboratory skill performance rubric developed by the researcher with seven levels of Laboratory Task Analysis Instrument (LAI) with a view of identifying areas of deficiency and then providing possible recommendations to higher education authorities in Ethiopia on how to improve the teaching and learning of practical biology in the country.

3.3 *Population and Sampling Techniques*

From all governmental universities in Ethiopia, three universities were purposefully selected as case study. There are two reasons why these universities are selected. Firstly, the universities have different length of work experiences and resources. University "A" or "aged University" has over 20 years of teaching experiences; University "B" or "middle-aged" has about 10 years of teaching experiences; and University "C" or "new University" has 6 years of experiences. Secondly, the locations of the universities to the researcher are appropriate to manage the data collection process properly and are found in the same administrative region. All the third year biology students, biology instructors and laboratory assistants were selected as sample of the study. Third year biology students were selected as samples of the study because they had already completed their intended laboratory works. The study was conducted with sample of 208 students (118 male and 90 female students), 26 instructors and 2 laboratory assistants.

3.4 *Instruments*

The research method for this study encompasses four instruments: rubrics for laboratory practical skill performance test, questionnaires for students and instructors, evaluation of laboratory organization, semistructured interview and Laboratory Task Analysis Instrument (LAI)

3.4.1 Rubrics

The rubrics (Appendix A) were developed by the researcher. The purpose of the rubrics was to test the laboratory skills performance of individual students the three basic biology laboratory manipulative skills. The three core manipulative laboratory tasks were identifying the basic biology laboratory equipment, accurate and precise use of light microscope and measuring weights and volumes.

3.4.2 Questionnaires for Students

The students' questionnaires were developed by the researcher in order obtain data regarding with students background, attitudes, and personal views of the biology laboratory activates. The questionnaires contain four parts that include 42 items (Appendix C). The first part includes demographic questions; the second part includes questions about students' back ground and attitudes, and the third part includes questions about students' personal views and believes they have undertaken in their three years of university biology laboratory practical skills, and the fourth part is evaluation of students laboratory practical skills based on the graduate profile set in the curriculum. The close-ended questionnaires were designed with Likert scale (1–5 scale).

3.4.3 Questionnaires to Instructors and Laboratory Assistants

The questionnaires were developed by the researcher in order to get data regarding instructors teaching experiences, attitudes and availability of laboratory materials, their practical skills and laboratory practical assessment methods (Appendix D). The questionnaires have five levels close-ended Likert scale questions and open-ended questions. The questionnaires contain three parts that include 42 items. The first part includes demographic questions; the second part includes questions about instructors'/laboratory assistants' background, attitudes and laboratory skill assessment methods. The third part includes availability and use of laboratory resources, and the fourth includes questions of laboratory practical skill assessment methods.

3.4.4 Laboratory Task Analysis Instrument

Laboratory Task Analysis Instrument (Appendix B) was developed from a modified version of Tweedy and Hoese (2005) laboratory task analysis inventory in order to analyze the laboratory manuals for their acquisition of the basic and integrated science process skills. The instrument was first developed by Tamir and Lunetta (1978) and German et al. (1996) with certain modification. There are two main reasons for the need to modify the laboratory task analysis used by Tweedy and Hoese (2005). Firstly, the measuring and using numbers and manipulative materials are incorporated here in this study because these skills are important science process skills that students should acquire in biology laboratory. Secondly, scientific communication is included in this study because it is an important science process skill. The Laboratory Task Analysis Instrument evaluates whether the student is asked to 1) prepare before laboratory, 2) plan and design , 3) measure and use numbers , 4) manipulate materials, 5) record results, make qualitative and quantitative relationships,6) draw conclusions, and 7) communicate and interpret the results.

3.5 *Procedures for Data Collection*

3.5.1 Laboratory Practical Skill Performance Test

The student course achievement in undergraduate biology program was measured by cumulative grade point average (CGPA). Researcher around the word used the GPA to measure the student course achievement (Galiher, 2006; Darling, Caldwell and Smith, 2005). They used GPA to measure student performance in particular semester. The research method for this study encompasses laboratory practical skill performance test for third year biology undergraduate students. Students' prior achievement of higher education entrance examination score obtained from students self report before performing the laboratory practical skill performance test.

Individual laboratory practical skill performance test was implemented to 55 randomly selected third year students from the selected universities (19 students from university A, 20 students from University B and 16 students from university C). The reason why only 55 third year biology students were administered with individual laboratory practical skill performance test is that the test is time taking. The test was designed with a specific strategy to assess three core manipulative laboratory skills:

- Identifying the basic biology laboratory equipment
- Accurate and precise use of light micropipette,
- Measuring weights and volumes

The three laboratory skills were selected for the reason that they are the basic and minimum laboratory practices for undergraduate biology students. The students' laboratory practical skill performances were assessed by a rubric. Every student was evaluated by two raters. The raters were all biology instructors who trained by the researcher for two hours how to evaluate the performance of each student and how to use the rubric.

The inter rater agreement was computed by the Spearman correlation coefficient as shown in Table 2 below, rho=0.86 which is significant (p=0.000) at the 0.01 level and the intra-class correlation coefficient between raters was 0.94.

Table 2: The inter rater agreement correlation coefficient and the intra-class correlation coefficient

			Rater1	Rater2
Spearman's rho	Rater1	Correlation Coefficient	1.000	0.858**
		Sig. (2-tailed)	.	0.000
		N	55	55
	Rater2	Correlation Coefficient	.858**	1.000
		Sig. (2-tailed)	.000	.
		N	55	55

**. Correlation is significant at the 0.01 level (2-tailed).

3.5.2 Questionnaires for Students and Instructors

A. **Students' Questionnaires:** Following the practical skill performance test, questionnaire was completed. A total of 252 printed questionnaires were distributed to be completed by the students over night and 208 (83.2%) completed questionnaires were returned from three universities (76 questionnaires from university "A", 65 questionnaires from university "B" and 67 questionnaires from university "C"). The questionnaires were distributed to the currently third year biology students and the completed questionnaires were analyzed using descriptive and inferential statistics using SPSS.

B. Questionnaires to Instructors and Laboratory Assistants: A total of 42 printed questionnaires were distributed to be completed over night by biology instructors and laboratory assistants and 28 (67%) completed questionnaires were returned from three universities (6 questionnaires from university "A", 12 questionnaires from university "B" and 10 questionnaires from university "C".

C. Interview for instructors and laboratory Assistants: From each university one instructor and one laboratory assistant were interviewed for about forty five minutes regarding the instructors experiences, the existence of laboratory manuals, the source and strength and weakness of the laboratory manuals, the major challenges they face to conduct laboratory work, the evaluation techniques they use to assess their students' performance in the laboratory works and the reasons, the availability of laboratory equipment and the number of field trips (appendix E). The interviews were conducted in the laboratories.

3.5.3 Evaluation of Laboratory Organization

Items of availability of biology laboratory equipment were assessed. These include microscopes, spectrophotometers, electrophoresis units, computers, and volume and weight measuring apparatus. The availability of the laboratory equipment were calculated by dividing each of the number of available equipment to the number of biology students in each university.

3.5.4 Analysis of Laboratory Manuals

Laboratory manuals are handbook, or worksheet (Hofstein and Lunetta, 2004) that should provide step-by-step detailed instructions (Germann et al.1996). Laboratory exercise is defined as an individual experiment or observation set up in a laboratory manual to investigate a particular problem or hypothesis (Peters, 2006).The available laboratory manuals used in each university were collected. All the laboratory manuals were not published but prepared by the instructors in the universities. Each activity in each course was evaluated with seven categories of Laboratory Task Analysis Instrument (LAI) modified version.

The laboratory exercise requirement of the Ethiopian Harmonized Curriculum for BSc Degree Program in biology (2009) syllabus was examined to gain information on the number and type of laboratory exercises recommended. Then, after the analysis of the curriculum syllabus, the analysis of the available biology laboratory manuals for each course in each university was conducted to get information in the number of laboratory exercises recommended to laboratory instructors. The basic and integrated science process skills were categorized in the seven categories (Appendix B).

A single laboratory exercise from each laboratory manual was assessed by the researcher and another evaluator. The inter-rater reliability was 83.5%. The collected data for each course was summarized at the university level. Then, the summarized data were added into the SPSS data file to analyze the variation among universities. The data obtained in the study were analyzed by using the SPSS statistical program.

3.6 *Validity and Reliability of the Instruments*

Validity is the accuracy of an instrument to measure what it is designed to measure. Reliability is the degree of consistency with which the same instrument measures under consistent conditions and getting the same result (Golafshani, 2003). Prior to administration, the laboratory practical skill performance test was submitted to a group four biology professors for an assessment of its content validity. The purpose of the content validation was to get the draft item moderated so as to be reliable.

The reliability of the students' and instructors' questionnaires was determined using pilot study. The purpose of the pilot research was to test adequacy of the questionnaires and to improve the internal validity of the questionnaires and test the effectiveness the statistical and analytical process (Simon, 2011).

The questionnaires were administered to all 42 third year biology students of the previous batch and 14 biology instructors. The data was analyzed using reliability analysis of the SPSS and the reliability of the instrument was Cronbach's alpha value of 0.91 and

0.83 for students and instructors' questionnaires respectively indicate that there is a high internal consistency (Tan, 2009).

3.7 *Data Analysis*

The collected data was transferred into the SPSS data file and the variation among universities was analyzed using the following methods:

3.7.1 Instructors and Students' Questionnaires

Descriptive statistics was used to find out the number of biology laboratory sessions per course being conducted in the sample universities and to summarize laboratory skill performance test results of universities and students perception on the acquisition of competences and skills prescribed on the harmonized curriculum.

Kruskal-Wallis Test was used to determine students' perception on the acquisition of students' competencies and skills in different universities. One way ANOVA was used to analyze the instructors' manipulative skills among the universities.

3.7.2 Laboratory Practical Skill Performance Test

Descriptive statistics was used to summarize the laboratory skill performance test results of the universities. Student's t- test and ANOVA were used to compare the achievement levels of the students who performed basic biology laboratory skill performance test in the universities.

Pearson correlation was used to determine whether there was a significant relationship (association) between the independent variables and students' laboratory practical skill performance. Multiple Regression analysis with linear function was used to find out the differential impact (causal-relationship) and T-test to compare the achievement levels of the students who performed basic biology laboratory skill performance test.

3.7.3 Analysis of Laboratory Manuals

Descriptive statistics was used to summarize and analyze the extent of the science process skills included in the laboratory manuals.

3.8 *Ethics*

The Institute for Science and Technology Education, UNISA ethical clearance application form has completed. The application for the ethical clearance was considered by the Institute for Science and Technology Education sub-committee in the College of Graduate Studies on the behalf of the UNISA research ethics review committee and approved (Appendix F). Permission from all individuals and universities participating were obtained prior to collecting personal information (appendix G). The confidentiality of all individuals was respected and name of the individuals and institutes involved in the questionnaires and interviews were remaining anonymous (appendix C and D) and other ideas are properly cited.

CHAPTER FOUR

4 RESULTS

This chapter focuses on the presentation of findings of the research and analysis of the data in order to answer the research questions

4.1 *The number of Practical Activities in Undergraduate Biology Laboratory Program*

Table 3: Number of laboratory session per courses conducting in sample universities

	Number of laboratory sessions/ course	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-2	44	21.2	21.7	21.7
	3-4	70	33.7	34.5	56.2
	5-6	32	15.4	15.8	71.9
	7-8	25	12.0	12.3	84.2
	9-10	9	4.3	4.4	88.7
	11-12	6	2.9	3.0	91.6
	13-14	14	6.7	6.9	98.5
	15-16	3	1.4	1.5	100.0
	Total	203	97.6	100.0	
Missing	System	5	2.4		
Total(N)		208	100.0		

From the Table 3 above, 56.2% of the students responded that they only had between one and four biology laboratory practical but the average recommended number of practical in the curriculum is 9 (the range is from 5 to 16) and the time allotted for each practical session is 3 hours. More than 84.2% of the laboratory activities are below the average number of laboratory activities recommended by the curriculum.

There is no significant difference between universities in the number of practical activities of undergraduate biology laboratory activities conducting.

Table 4: Percent of laboratory activities implemented as surveyed from instructors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-20%	8	28.6	28.6	28.6
	21-40%	7	25.0	25.0	53.6
	41-60%	4	14.3	14.3	67.9
	61-80%	4	14.3	14.3	82.1
	81-100%	5	17.9	17.9	100.0
	Total(N)	28	100.0	100.0	

The number of implemented practical laboratory sessions from the recommended practical sessions in the curriculum is from 11% to 80%. About 53.6% of the instructors agreed that only up to 40% of the recommended laboratory activities are performed in the universities (see Table 4).

From instructors interview and open-ended questions, the reasons for the low number of implementation of the laboratory practical are lack of facilities and lack of laboratory manuals and references, large class size, shortage of time, low payment rate, low encouragement, lack of laboratory manuals, absence of specimens, lack of proper laboratory set up and lack of laboratory technicians, shortage of laboratory rooms and shortage of professionals.

Table 5: Rank of biology courses where students did more laboratory practical activities

Course name	Rank from the three universities	Rank from University A	Rank from University B	Rank from University C
Introduction to Biological Laboratory Techniques	1	1	1	1
Phycology	5	11	8	3
Bryophytes and Pteridophytes	10	4	9	13
Seed Plants	6	3	4	7
Invertebrate Zoology	9	2	11	12
Vertebrate Zoology	12	4	12	14
Cell Biology	7	8	6	6
Mycology	3	6	5	4
General Entomology	11	9	10	10
Principles of Genetics	13	13	13	11
Principles of Parasitology	8	10	3	8
General Microbiology	2	7	2	5
Plant Physiology	4	14	7	2
Applied Entomology	14	12	14	9

The students were asked to rank the laboratory practical activities for biology courses they did from 1 to 14, where 1 for most and 14 for least. As shown in Table 5 above, Introduction to Biological Techniques was rated first in which students did more practical activities in the three universities. However, ranks of other courses were greatly varied from university to university. This may be due to the differences in instructors, experience, availability of laboratory equipment and manuals.

4.2 *The Extent of Biology Students Acquire the Competencies and Skills Prescribed in the Graduate Profile*

Ten Likert scale questions (Appendix C-IV) on a scale of 1 (strongly disagree) to 5 (strongly agree) about the acquisition of competencies and skills were administered to 208 students in the sample universities. Students perceived that they have the ability to perform the competences and skills prescribed on the undergraduate biology curriculum. As shown in Table 6, more than 51% of the students agreed and 24 % strongly agreed that they have the ability to perform the competencies and skills prescribed on the biology curriculum. About 25%, of the students disagreed or not sure about their ability to perform the competencies and skills prescribed on the biology curriculum of the old, the middle and new universities respectively.

As shown in Table 6, there was no significant difference in participants' responses about the acquisition of competencies and skills for question number 1, 2, 3, 7, 8, 9 and10. However, there was a significant difference in the acquisition of competencies and skills for question number 4, 5 and 6. University B and university C had the higher mean rank than university C (the older university).

Table 6: Students response on the acquisition of competencies and skills prescribed on the harmonized biology curriculum

	Competencies	Strongly Disagree			Disagree			Not Sure			Agree			Strongly Agree		
		University A N=76	University B N=63	University C N=67	University A N=76	University B N=63	University C N=67	University A N=76	University B N=63	University C N=67	University A N=76	University B N=63	University C N=67	University A N=76	University B N=63	University C N=67
1	I am able to relate things learned in the class to daily life, transform them into practice and solve problems		0	0	2	3	0	7	6	2	53	38	56	13	16	9
		3%	0%	0%	2.6%	4.6%	0%	9.2%	9.2%	3.%	69.7%	58.5%	83.6%	17.1%	24.6%	13.4%
2	I am able to do experiments, and to use laboratory equipment	2	0	0	3	0	0	11	4	5	39	40	46	21	19	16
		2.6%	0%	0%	3.9%	0%	0%	14.5%	6.2%	7.5%	51.3%	61.5%	68.7%	27.6%	29.2%	23.9%
3	I can design a scientific procedure to answer question	1	0	0	6	4	2	10	18	24	39	34	31	20	7	10
		1.3%	0%	0%	7.9%	6.2%	3%	13.2%	27.7%	35.8%	51.3%	52.3%	46.3%	26.3%	10.8%	14.9%
4	I am able to conduct researches in various biological disciplines	0	1	0	5	3	2	11	10	17	41	38	36	19	11	11
		0%	1.5%	0%	6.6%	4.6%	3%	14.5%	15.4%	25.4%	53.9%	58.5%	53.7%	25.0%	16.9%	16.4%
5	I am able to collect data systematically, catalogue and preserve field biological materials and museum specimens of plants, animals and microbes	4	1	1	2	3	6	19	6	12	38	35	36	13	18	12
		5.3%	1.5%	1.5%	2.6%	4.6%	9%	25%	9.2%	17.9%	50%	53.8%	53.7%	17.1%	27.7%	17.9%
6	I am able to apply the techniques of culture media, and carry out culturing, isolation and identification of micro-organisms and report	2	1	1	5	2	3	13	5	5	35	26	35	21	28	23
		2.6%	1.5%	1.5%	6.6%	3.1%	4.5%	17.1%	7.7%	7.5%	46.1%	40.0%	52.2%	27.6%	43.1%	34.3%
7	I am able to analyze and interpret biological data and write and present scientific reports	1	2	1	3	2	5	14	8	7	37	31	37	21	20	16
		1.3%	3.1%	1.5%	3.9%	3.1%	7.5%	18.4%	12.3%	10.4%	48.7%	47.7%	55.2%	27.6%	30.8%	23.9%
8	I am able to operate basic biological equipment	2	0	1	5	3	3	13	10	17	38	38	28	18	11	18
		2.6%	0%	1.5%	6.6%	4.6%	4.5%	17.1%	15.4%	25.4%	50%	58.5%	41.8%	23.7%	16.9%	26.9%
9	I am able to solve environmental and conservation problems of the Country.	3	0	0	1	3	4	13	7	8	33	38	32	26	15	22
		3.9%	0%	0%	1.3%	4.6%	6%	17.1%	10.8%	11.9%	43.4%	58.5%	47.8%	34.2%	23.1%	32.8%
10	I can design ways to prevent infectious diseases	1	0	2	2	3	2	8	4	3	38	34	32	27	21	28
		1.3%	0%	3%	2.6%	4.6%	3%	10.5%	6.2%	4.5%	50%	52.3%	47.8%	35.5%	32.3%	41.8%
	Total	17	5	6	34	26	27	119	78	100	391	352	369	199	166	165
		2.2%	0.8%	0.9%	4.5%	4.1%	4.0%	15.7%	12.4%	15.0%	51.4%	56.1%	55.3%	26.2%	26.5%	24.7%

Table 7: Kruskal-Wallis Test about students' response on the acquisition of competencies and skills in different universities

Q1	Skills	University	N	Mean Rank
1	I am able to relate things learned in the class to daily life, transform them into practice and solve problems	A	76	99.73
		B	63	106.44
		C	67	105.01
		Total	206	
2	I am able to do experiments, and to use laboratory equipment	A	76	96.92
		B	63	110.69
		C	67	104.20
		Total	206	
3	I can design a scientific procedure to answer question	A	76	115.57
		B	63	96.06
		C	67	96.80
		Total	206	
4	I am able to conduct researches in various biological disciplines	A	76	108.82
		B	63	102.01
		C	66	97.25
		Total	205	
5	I am able to collect data systematically, catalogue and preserve field biological materials and museum specimens of plants, animals and microbes	A	76	95.64
		B	63	117.47
		C	67	99.28
		Total	206	
6	I am able to apply the techniques of culture media, and carry out culturing, isolation and identification of micro-organisms and report	A	76	91.35
		B	62	114.85
		C	67	105.25
		Total	205	
7	I am able to analyze and interpret biological data and write and present scientific reports	A	76	101.91
		B	63	108.06
		C	67	101.01
		Total	206	
8	I am able to operate basic biological equipment	A	76	102.90
		B	62	103.56
		C	67	102.59
		Total	205	
9	I am able to solve environmental and conservation problems of the Country.	A	76	104.14
		B	63	100.05
		C	67	106.02
		Total	206	
10	I can design ways to prevent infectious diseases	A	76	100.36
		B	62	100.73
		C	67	108.09
		Total	205	

The questions were analyzed inferentially with the Kruskal-Wallis Analysis of Variance test (Table 7), with the age of university being the independent variable. The results indicate that there were no significant differences in participants' responses on a scale of 1 (strongly disagree) to 5 (strongly agree).

Table 8: Rank of biology courses where students acquire most important skills for their life career from the laboratory practical

Code	Course name	Rank from all the three universities	Rank from University A	Rank from University B	Rank from University C
A	Introduction to Biological Laboratory Techniques	1	1	1	1
B	Phycology	5	11	8	3
C	Bryophytes and Pteridophytes	10	4	9	13
D	Seed Plants	6	3	4	7
E	Invertebrate Zoology	9	2	11	12
F	Vertebrate Zoology	12	4	12	14
G	Cell Biology	7	8	6	6
H	Mycology	3	6	5	4
I	General Entomology	11	9	10	10
J	Principles of Genetics	13	13	13	11
K	Principles of Parasitology	8	10	3	8
L	General Microbiology	2	7	2	5
M	Plant Physiology	4	14	7	2
N	Applied Entomology	14	12	14	9

Students were also asked to rank the biology courses they acquire most important skills for their life career from 1 to 14, where 1 for most and 14 for least. As shown in Table 8 above, the students' perception regarding the importance of the biology laboratory practical activities for their life career varied from university to university indicating that student's attitudes might be affected by in instructor's experience, availability of laboratory equipment and manuals.

Table 9: Laboratory skill performance test results of universities

	Weight of score	University A			University B			University C		
		N	Mean	Std. Deviation	N	Mean	Std. Deviation	N	Mean	Std. Deviation
GPA		16	2.80	0.46	16	2.74	0.55	19	2.71	0.63
Identification of laboratory equipment	10	16	7.25	3.04	20	5.40	3.36	19	7.16	2.65
Function of laboratory equipment	10	16	7.63	2.63	20	4.90	3.09	19	5.16	2.81
Handling of microscope	4	16	3.47	0.72	20	1.68	0.98	19	1.92	0.87
Setting of microscope	4	16	3.53	0.81	20	2.25	0.79	19	2.21	0.56
Mounting of specimen	4	16	3.19	0.85	20	1.73	0.75	19	1.76	0.82
Staining of specimen	4	16	2.09	1.37	20	1.93	1.02	19	1.63	0.88
Focusing of a microscope from low to high power objectives	4	16	2.56	0.60	20	1.85	0.81	19	1.58	0.65
Estimation of diameter of field of vision	4	16	0.00	0.00	19	0.00	0.00	19	0.00	0.00
Drawing of specimen seen in the microscope	4	16	1.06	1.06	19	0.26	0.56	19	0.11	0.32
Measuring liquid in liter, ml and µl	4	16	1.47	1.06	20	0.50	0.58	19	0.61	0.91
Measuring weight in gm, mg and µg	5	16	1.34	0.85	20	0.90	0.60	19	0.42	0.75
Total	57		36.39	13.45		24.14	13.09		25.27	11.85

Laboratory skill performance test was carried out for 55 students in the three universities with a rubric (Appendix A). The score was evaluated out of 60 marks. As can be seen in Table 9 above, students performed better in identification of laboratory equipment (6.55±3.11) and function of laboratory equipment (5.75±3.06).

The most challenging skills for the students were estimation of diameter of field of vision, focusing, setting of microscope, mounting, staining, drawing and measuring weight and liquid. None of the students were able to estimate and determine the field of vision of a microscope. The highest score (33.39±6.46) was obtained by students in the aged university and least score (21.4±9.55) was obtained by students in the middle-aged university.

Table 10: Skill Performance Test Result Between- Universities t-test (p<0.05)

Universities	**N**	**Mean**	**STDEV**	**Between universities**	**p**
A(old)	16	33.60	6.46	Between A and B	0.00006
B(middle-aged)	20	21.38	9.55	Between A and C	0.00006
C(new)	19	22.56	7.70	Between B and C	0.67

The results of the analysis regarding the differences between universities in laboratory skill performance were examined by student's t-test (see Table 10). There is a high significant difference among the three universities. However, there is no significant difference between the middle-aged and the new universities.

Table 11: One way ANOVA analysis of students' performance test scores of various activities among universities

		Sum of Squares	df	Mean Square	F	Sig.
Identification of laboratory equipment	Between Groups	41.310	2	20.655	2.236	0.117
	Within Groups	480.326	52	9.237		
	Total	521.636	54			
Function of laboratory equipment	Between Groups	77.306	2	38.653	4.695	0.013*
	Within Groups	428.076	52	8.232		
	Total	505.382	54			
Handling of microscope	Between Groups	32.378	2	16.189	21.310	0.000**
	Within Groups	39.503	52	.760		
	Total	71.882	54			
Setting of microscope	Between Groups	19.203	2	9.602	18.395	0.000**
	Within Groups	27.142	52	.522		
	Total	46.345	54			
Mounting of specimen	Between Groups	23.668	2	11.834	18.174	0.000**
	Within Groups	33.859	52	.651		
	Total	57.527	54			
Staining of specimen	Between Groups	1.941	2	.971	.818	0.447
	Within Groups	61.668	52	1.186		
	Total	63.609	54			
Focusing of a microscope from low to high power objectives	Between Groups	8.808	2	4.404	8.939	0.000**
	Within Groups	25.619	52	.493		
	Total	34.427	54			
Estimation of diameter of field of vision	Between Groups	.000	2	.000	a.	.a
	Within Groups	.000	51	.000		
	Total	.000	53			
Drawing of specimen seen in the microscope	Between Groups	8.922	2	4.461	9.320	0.000**
	Within Groups	24.411	51	.479		
	Total	33.333	53			
measuring liquid in liter, ml and µl	Between Groups	9.658	2	4.829	6.604	0.003**
	Within Groups	38.024	52	.731		
	Total	47.682	54			
measuring weight in gm, mg and µg	Between Groups	7.436	2	3.718	6.957	0.002**
	Within Groups	27.791	52	.534		
	Total	35.227	54			

**Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The biology laboratory skill performance test result was computed by one way ANOVA to determine whether there is a significant difference in specific skill or not. As shown in Table 11 above, there is a significant difference in the biology laboratory skill performance.

Table 12: Correlation between laboratory skills performance and other independent variables

Skill		Sig. (1-tailed)
	Higher education entrance exam score	0.003
	High school laboratory back ground	0.167
	Maximum number of laboratory session	0.233
	Availability Laboratory resource	0.003
	Instructors' experience	0.000
	Instructors' qualification	0.011
	Instructors' manipulative skills	0.326
	Efficient use of laboratory	0.110

Correlation and multiple regression analyses were conducted to examine the relationship between third year biology under graduate students' laboratory performance skill and various potential predictors, such as higher education entrance exam score, high school background, number of laboratory sessions they conducted, availability of laboratory resources, instructors experience, instructors' qualification, instructors' manipulative skills and efficient use of laboratory resources. The multiple regression model with all predictors produced $R^2 = .355$, $F(5, 47) = 5.174$, $p < .001$. As can be seen in the correlation in Table 12, students' laboratory performance skills is significantly positively correlated with their higher education entrance exam score, availability of laboratory resources and instructors' experience indicating that those with higher scores on these predictive variables tend to have higher students laboratory performance skills. Instructors' experience had significant positive regression weights.

4.3 *The relationship between the availability/unavailability of laboratory equipment and the students' laboratory skill performance*

Table 13: Availability of Laboratory Equipment in the universities

University	No students	No. of laboratory	No. of microscope	Spectrophotometer	Electrophoresis	Computers	Graduating cylinder	pipettes	Micro pipettes	Beam balance	Micro balance	Autoclave	Incubators	Oven	Bunsen burner	Total
A	97	0.07	0.52	0.01	0	0.06	0.10	1.03	0.04	0.06	0.08	0.03	0.04	0.01	0.1	2.15
B	68	0.03	0.44	0	0.04	0.02	0.22	0.74	0.04	0.03	0.07	0.03	0.04	0.02	0	1.72
C	87	0.02	0.23	0.01	0	0.01	0.03	0.35	0	0.01	0.01	0.01	0.01	0.01	0	0.7

The value of the availability of laboratory equipment was determined by index *(the index* $= \frac{Number\ of\ equipments}{Number\ of\ students}$*).* As shown in Table 13 above, the availability of laboratory equipment is related with the age of the universities in that the older university has the highest value (2.15) and the new university has the least value (0.7).

4.4 *Instructors' Manipulative Skills and Teaching Experience*

Table 14: Frequencies of Instructor's manipulative skills to conduct experiments

		Use of microscope	Use of Spectrophotometer	Use of Electrophoresis	Use of LCT	Use of Qualitative food test	Culturing	Culturing fungi	Preservation	staining
N	Valid	28	27	26	27	28	28	28	27	27
	Missing	0	1	2	1	0	0	0	1	1
Mean		4.25	2.63	2.15	2.19	3.68	3.71	3.21	3.41	2.89
Median		4.00	2.00	1.00	2.00	4.00	4.00	3.00	4.00	3.00
Mode		4	1	1	1	4	5	3	4	2
Std. Deviation		.752	1.597	1.515	1.302	1.249	1.182	1.343	1.185	1.251
Variance		.565	2.550	2.295	1.695	1.560	1.397	1.804	1.405	1.564
Range		3	4	4	4	4	4	4	4	4
Sum		119	71	56	59	103	104	90	92	78
Percentiles	10	3.00	1.00	1.00	1.00	1.90	2.00	1.00	1.80	1.00
	20	4.00	1.00	1.00	1.00	2.00	2.80	2.00	2.00	2.00
	30	4.00	1.00	1.00	1.00	3.00	3.00	2.00	3.00	2.00
	40	4.00	1.20	1.00	1.00	4.00	3.60	3.00	3.20	2.00
	50	4.00	2.00	1.00	2.00	4.00	4.00	3.00	4.00	3.00
	60	4.40	3.80	2.00	2.00	4.00	4.00	3.40	4.00	3.00
	70	5.00	4.00	3.00	3.00	4.30	5.00	4.00	4.00	3.60
	80	5.00	4.00	3.60	4.00	5.00	5.00	5.00	4.00	4.00
	90	5.00	5.00	5.00	4.00	5.00	5.00	5.00	5.00	5.00

Descriptive analysis of Likert Scale (from 1 poor to 5 excellent) was used to determine instructors' manipulative skills to conduct experiments on the use of light microscope, spectrophotometer, electrophoresis, liquid chromatography techniques, qualitative food test, microbial culturing, isolation and gram staining techniques, culturing and growing of fungi species, collection and preservation of insects and staining and identification of chromosomes during cell division (see Table 14). The skills are prescribed in the under graduate biology curriculum as the graduate profile.

Instructor's self-reported results about their manipulative skills showed that (Table 14) about 89% of the instructors can manipulate microscope and about 70% of the instructors can do qualitative food test, culturing fungi and preserving animals. However, over 65% of the instructors do not have good manipulative skills to conduct experiments using electrophoresis; and 50% of the instructors do not have manipulative skills to conduct experiments using spectrophotometer, liquid chromatography and staining techniques.

Table 15: One way ANOVA analysis in instructors' manipulative skills among universities

		Sum of Squares	df	Mean Square	F	Sig.
Use of microscope	Between Groups	.016	2	.008	.013	0.987
	Within Groups	15.234	25	.609		
	Total	15.250	27			
Spectrophotometer	Between Groups	11.897	2	5.949	2.625	0.093
	Within Groups	54.399	24	2.267		
	Total	66.296	26			
Electrophoresis	Between Groups	5.885	2	2.942	1.314	0.288
	Within Groups	51.500	23	2.239		
	Total	57.385	25			
LCT	Between Groups	2.852	2	1.426	.830	0.448
	Within Groups	41.222	24	1.718		
	Total	44.074	26			
Qualitative food test	Between Groups	.726	2	.363	.219	0.805
	Within Groups	41.381	25	1.655		
	Total	42.107	27			
Culturing	Between Groups	1.857	2	.929	.647	0.532
	Within Groups	35.857	25	1.434		
	Total	37.714	27			
Culturing fungi	Between Groups	4.052	2	2.026	1.134	0.338
	Within Groups	44.663	25	1.787		
	Total	48.714	27			
Preserving specimen	Between Groups	4.269	2	2.134	1.588	0.225
	Within Groups	32.250	24	1.344		
	Total	36.519	26			
Staining specimens	Between Groups	6.417	2	3.208	2.248	0.127
	Within Groups	34.250	24	1.427		
	Total	40.667	26			

One way ANOVA analysis (Table 15) revealed that there is no significant difference in instructors' manipulative skills among universities ($p \geq 0.09$). Pearson correlation analysis shows that instructors manipulative skills is neither correlated with qualification nor teaching experience ($P \geq 0.056$).

4.5 *Laboratory Practical Assessment Methods Used by Instructors*

Table 16: Assessment method of the laboratory practical activities

		University				%
		A	B	C	Total	
Assessment method	Paper and pencil	0	0	2	2	7.14%
	Identification of specimen	1	0	1	2	7.14%
	Laboratory report and attendance	0	1	0	1	3.57%
	Laboratory report and Identification of specimen	1	9	3	13	46.43%
	Laboratory report and written	5	2	3	10	35.72%
Total		7	12	9	28	100%

The results show that about 46.4% of the instructors use laboratory report and identification of specimen and 35.7% of the instructors use laboratory report and written examinations (Table 16). From the instructors' questionnaires and interviews, the results indicate that the instructors believe that these forms of assessment help to evaluate the students' knowledge and skills, to include all concepts, to assess students' ability, to address the diversity of students learning style and to develop students' skills in writing laboratory reports. The instructors also mentioned that written examinations are appropriate methods because they help the instructors' to check whether the students conducted the practical individually, understood the practical and to evaluate how much the students remember the observations they made.

4.6 *The Relationship between the Biology Laboratory Skill Performance and Students Course Achievement (GPA)*

4.6.1 The relationship between higher education entrance exam scores and undergraduate students' course achievement

Table 17: Results of the Pearson's Correlation Analysis of GPA and Laboratory skill performance activities test score

N=55	**Correlation r (correlation coefficient**	**P significance level**
GPA-ILE	0.362	0.009*
GPA-FLE	0.204	0.152
GPA-HM	0.312	0.026*
GPA-SM	0.363	0.006*
GPA-M	0.150	0.293
GPA-Staining	0.057	0.094
GPA-Focusing	0.213	0.133
GPA-EDFV	0.000	0.000*
GPA-Drawing	0.231	0.107
GPA-ML	0.283	0.044*
GPA-MW	0.254	0.072

*Correlation is significant at the 0.05 level

An examination of the results of the Pearson's correlation analysis (Table 17) revealed that cumulative grade point average (GPA) is positively and significantly correlated with higher education entrance exam score and biology laboratory test scores but not with sex and prior high school and preparatory biology laboratory background.

4.6.2 The relationship between high school laboratory experience and undergraduate biology laboratory practical skills

There is also a significant correlation between higher education entrance exam score (HEEES) and laboratory skill performance activities test score ($p<0.005$). However, biology laboratory skill test score is not significantly correlated with sex and prior high school and preparatory school biology laboratory background.

Students' course achievement (GPA) is significantly and a positively related with some of laboratory skill performance test scores, such as identification of lab equipment, handling of microscope, setting of microscope, estimation of diameter of field of vision, measuring liquid. The grade point average (GPA) was also significantly and positively related with higher education entrance exam score ($p<0.009$). This may be due to students academic back ground and individual differences.

An examination of the results of the Pearson's correlation analysis (Table 17) revealed that there is a significant and a positively linear relationship between the students' GPA with identification of lab equipment (ILE), handling of microscope(HM), setting of microscope(SM), estimation of diameter of field of vision(EDFV), measuring liquid(ML) but not correlated with some of lab skill performance activities such as function of lab equipments(FLE), mounting (M),staining, focusing, drawing and measuring weight(MW). There is a significant relationship between higher education entrance exam score (HEEES) and grade point average ($p<0.009$).

Table 18: Multiple regression model summary of the predictor variable

	Unstadardized Coefficient		Standardized Coefficient			Collinearity Statistics	
	B	Std. Error	Beta	T	Sig.	Tolerance	VIF
Constant	2.104	0.267		7.878	0.000		
High school laboratory back ground	-0.064	0.036	-0.127	-1.754	0.081	0.980	1.021
Sex	-0.231	0.078	-0.214	-2.945	0.004	0.969	1.032
Higher education entrance exam score	0.003	0.001	0.291	4.041	0.000	0.981	1.020
Maximum number of laboratory session	0.027	0.018	0.111	1.551	0.123	0.989	1.011

a. Dependent Variable: GPA

Correlation and multiple regression analyses were made to examine the relationship between third year biology under graduate students' grade point average (GPA) and various potential predictors, such as their sex, high school background, higher education entrance examination score, and number of laboratory sessions they conducted. The multiple regression model with all the four predictors produced $R^2 = .189$, $F(4, 163) = 9.257$, $p < .000$. As can be seen in Table 18, sex is negatively correlated with third year biology under graduate students' GPA (coded as 0=Male and 1=Female), indicating that the male students have a larger GPA. Moreover, students' high school background is negatively correlated with their GPA. Students' higher education entrance examination score and number of laboratory sessions they conducted have significant positive regression weights, indicating that students with higher scores on these scales were expected to have higher GPA.

4.7 *The Prominent Science Process Skills Included in the Undergraduate Biology Laboratory*

Table 19: The biology laboratory exercise analysis inventory of manuals in different universities

Description of Evaluation criteria	**University A (Old)**	**University-B (Middle-aged)**	**University A (New)**	**Total activities**	**%**
Number of courses with manuals	13	7	2	22	
Total Number of laboratory activities recommended in the manuals	90	52	14	156	
I. **Pre-Lab Activities**					
a. Reading	81	52	14	147	17.63
b. Questions	9	-	2	11	1.32
c. Observations	9	-	1	10	1.20
Total	**99**	**52**	**17**	**168**	**20.14**
II. **Planning and Designing**					
a. Formulates question/problem	-	-	-		0.00
b. Formulates hypothesis	-	-	-		0.00
c. Identifies independent variable	-	-			0.00
d. Identifies dependent variable	-	1	-	1	0.12
e. Identifies constant variables	-	1	-	1	0.12
f. Experimental control	-	6	-	6	0.72
g. Designs observations	-	1	-	1	0.12
h. Designs experiments	-	-	-	0	0.00
i. Designs data table	-	-	-	0	0.00
j. Predicts experimental results.	-	1	-	1	0.12
Total	**0**	**10**	**0**	**10**	**1.20**
III. Measuring and Using Numbers					
a. Identify the measurement required.	24	17	7	48	5.76
b. Specify the instrument to be used.	21	14	7	42	5.04
c. Choosing and using standard unit	17	13	7	37	4.44
d. Add up the total measurement	15	8	4	27	3.24
e. Recording unit correctly	17	12	3	32	3.84
f. Comparing time, distance, area and volume with relevant units	7	11	4	22	2.64
Total	**101**	**75**	**32**	**208**	**24.94**
IV. Manipulate Materials					
a. *Using and handling science apparatus*	28	36	18	82	9.83
b. *Maintaining science apparatus correctly and safely*	11	-	-	11	1.32
c. Cleaning science apparatus correctly	7	8	2	17	2.04
d. Handling specimen correctly and carefully	47	21	16	84	10.07
e. Sketch specimen and science apparatus	20	3	-	23	2.76
Total	**113**	**68**	**36**	**217**	**26.02**

V. Record Results, Make Qualitative and Quantitative Relationships					
a. Recording information from investigations	5	6	2	13	1.56
b. Results summarized in a table	4	6	1	11	1.32
c. Graphs data	1	2	8	11	1.32
d. Determines qualitative relationships	22	25	6	53	6.35
e. Determines quantitative relationships	6	5	3	14	1.68
f. Determines accuracy of experimental data	-	1	-	1	0.12
Total	**38**	**45**	**20**	**103**	**12.35**
VI. Draw Conclusions, Make Inferences and Generalizations					
a. Draws conclusions	34	22	10	66	7.91
b. Provides evidence	2	3	1	6	0.72
c. Discusses limitations/assumptions	5	4	1	10	1.20
d. Formulates generalization/ model	6	1	-	7	0.84
e. Makes inferences	1	1	1	3	0.36
Total	**48**	**31**	**13**	**92**	**11.03**
VII. Communicate and Interpret The Results					
a. Express ideas or meanings	-	13	1	14	1.68
b. Drawing and making notes	13	1	1	15	1.80
c .Writing experiment report to enable others to repeat the experiment	1	1	-	2	0.24
d. Using references	1	2	2	5	0.60
Total	**15**	**17**	**4**	**36**	**4.32**
Grand Total	**414**	**298**	**122**	**834**	
%	**49.64**	**35.73**	**14.63**	**100**	

The Harmonized Curriculum for BSc Degree Program in Biology (Addis Ababa, Ethiopia, 2009) recommends that 146 laboratory practical sessions and 7 field trips in 15 courses throughout the entire program. As shown in Table 19 above, a total of 22 biology laboratory manuals in the three universities were evaluated with seven categories of Laboratory Task Analysis. The number of courses having laboratory manuals are 2 (14.3%), 7 (50%) and 13 (92.86%) in the new, middle-aged and old universities respectively. The number of laboratory sessions recommended by the manuals are 90(61.4%), 52 (35.6%) and 14(9.6%) in the new, middle-aged and old universities respectively. A total of 838 activities were given in the manuals of the three universities.

Of these, 416 (49.64%), 298 (35.73%) and 122 (14.63%) activities are in the old, middle-aged and new universities respectively. The seven categories of Laboratory Task Analysis Instrument used in the study in their decreasing order were manipulating materials (26.02%), measuring and using numbers (24.94%), pre-lab activities, such as reading, observation and questioning (20.14%), recording results, making qualitative and quantitative relationships(12.35%), drawing conclusion, making inferences, and making generalization(11.03%), communicating and interpreting results(4.32%) and planning and designing(1.2%) Manipulating materials, measuring and using numbers and pre lab activities were the common activities, and were found in every manual and in all the three universities. However, students were rarely asked to plan and design and to communicate and interpret the results. The results of this study also show high percentage rate of basic science process skills (75.4%) as compared to the integrated science process skills (24.6%).

4.7.1.1 **Pre -lab Activities**

As shown in Table 19 (I) above, reading was the most common pre-lab activity (17.63%) and was found in every manual and every university. Answering initial questions and preliminary observations were present only in two manuals of the old and new universities, each in a single activity occurred in 9% and 2% of the activities.

4.7.1.2 **Planning and Designing**

As shown in Table 19 (II) above, reading was the most common pre-lab activity (1.2%) and was found only in the middle-aged university. Three manuals required students to plan and design their experiments in the middle- aged university. In one activity, students were asked to identify independent and dependent variables, in three activities to use experimental control, in one activity to design observation, and in a single activity to predict experimental results. None of the manuals asked students to formulate questions and hypothesis, to identify independent variables, design their experiment and design data tables.

4.7.1.3 **Measuring and Using Numbers**

As shown in Table 19 (III) above, students are most often asked to identify the measurement required, specify the instrument to be used, choosing and using standard units, add up the total measurements, recording units correctly and comparing time, distance, area and volume with relevant units in most manuals of all the three universities.

4.7.1.4 **Manipulating Materials**

As shown in Table 19 (IV) above, using and handling science apparatus (9.83%) and handling specimen correctly and carefully (10.07%) were the most frequently asked activities among the skills of manipulating materials. Maintaining science apparatus correctly and safely and sketching specimen and science apparatus were rarely asked activities in the manuals.

4.7.1.5 **Recording Results, Make Qualitative and Quantitative Relationships**

Students were most often asked to perform qualitative relationship than quantitative relationship and were rarely asked to summarize their data in tables and graphs (Table 19, V). They were asked to determine the accuracy of the observed experimental data only in a single activity.

4.7.1.6 **Drawing Conclusions, Making Inferences and Generalizations**

Students were required to draw conclusions based on the results, but they were rarely required to support their conclusions with evidence, to discuss the limitations or assumptions, to formulate model and to make inferences (Table 19, VI).

4.7.1.7 **Communicating and Interpreting the Results**

Students were rarely asked to express their ideas or meanings, to record information from investigations, to draw and make notes, to write experiment reports to enable others to repeat the experiment and to use references. None of the manuals asked students to use and explain the meaning of symbols.

Table 20: Students evaluation on the laboratory manuals

Course name	Mean of all the three universities	Mean of University A	Mean of University B	Mean of University C
Introduction to Biological Laboratory Techniques	3.78	3.95	4.23	3.15
Phycology	2.74	3.05	2.52	2.58
Bryophytes and Pteridophytes	2.81	3.63	3.29	1.44
Seed Plants	3.04	3.52	3.7	1.88
Invertebrate Zoology	2.74	3.74	2.9	1.45
Vertebrate Zoology	2.67	3.58	2.79	1.50
Cell Biology	3.09	3.54	3.03	2.65
Mycology	3.26	3.69	3.44	2.63
General Entomology	2.54	3.50	2.62	1.39
Principles of Genetics	2.47	3.16	2.5	1.65
Principles of Parasitology	3.11	3.32	4.21	1.85
General Microbiology	3.51	3.48	4.24	2.85
Plant Physiology	3.35	3.09	3.75	3.26
Applied Entomology	2.23	3.22	1.81	1.4

In the questionnaires, students were asked to evaluate the laboratory manuals of biology courses with 5 level of Likert Scale (1=no manual, 2=not good, 3=good, 4=very good and 5=excellent).As shown in Table 20 above, the old university and the middle-aged university have at average good and very good laboratory manuals at all. However, the new university has two good manuals while others are not good or have no manuals. This coincides with the Laboratory Task Analysis of the laboratory manual in this study.

Table 21: Number of field trips conducted in the undergraduate program

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None	53	24.8	26.2	26.2
	1 time	15	7.0	7.4	33.7
	2 times	25	11.7	12.4	46.0
	3 times	92	43.0	45.5	91.6
	4 times	15	7.0	7.4	99.0
	5 times	2	.9	1.0	100.0
	Total	202	94.4	100.0	
Missing	System	12	5.6		
Total		214	100.0		

Survey from students demonstrated that about 90% of the students agreed that field trips help them to understand the real biological situations. The numbers of field trips conducted in the universities vary from university to university; three times in the old and middle-aged universities and only a single field trip in the new university. As shown in Table 21 above, 91.6% of the students agreed that the number of field trips conducted in the biology undergraduate program of the sample universities is less than three times.

CHAPTER FIVE

5 SUMMARY OF FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATION

This chapter provides summary of findings for the research questions, discussions and conclusions. The chapter ends by giving some recommendations..

5.1 *Summary of Findings*

1. Fewer laboratory activities were being conducted than are recommended in the curriculum guide out line.

2. The laboratory skill performance test is low especially in manipulative skills. Students perform more on basic science process skills than on integrated science process skills.

3. The laboratory skill performance test results are significantly and positively correlated with higher education entrance exam score, availability of laboratory resources, instructors' experience, teachers' qualification and efficient use of laboratory resources. The laboratory skill performance results differ significantly among universities. Instructors' experience had significant positive regression weight.

4. More than 65% of the instructors have poor laboratory manipulative skills in spectrophotometer, electrophoresis, liquid chromatography techniques, culturing of microorganisms, cultivation of fungi and staining microscope specimens.

5. More than 80% of instructors use laboratory report and written examination to evaluate the performance of students in laboratory activities. Although, performance assessments require more time to administer than do other forms of assessment, it is appropriate to evaluate students' laboratory skill performance. However, practical methods of assessing students' performance have given minimum attention.

6. There is significant and positive linear correlation between students competence in particular skills and higher education entrance exam scores. However, there is no association between undergraduate biology laboratory skill performance results and prior laboratory back ground in the secondary and preparatory schools.

7. Field trip has given minimum attention in the universities.

8. The laboratory manuals possess high percentage rate of basic science process skills (75.4%) as compared to the integrated science process skills (24.6%).

9. The study showed that practical methods of assessing students' performance need more attention

5.2 *Discussion*

Sabri and Emuas (1999) showed that there is a strong relationship between the total number of secondary science laboratory experiments in secondary school and the academic achievement of Palestinian students in science theory and laboratory courses. The result of this study is in agreement with those of Gardiner (1999). Gardiner (1999) also stated that fewer biology laboratory activities were being conducted than are recommended in the curriculum guide outline in British Columbia high schools.

In this study, the analysis of the instructor's response revealed that fewer laboratory activities were being conducted than are recommended in the curriculum guide outline. More than 82.4% of the laboratory activities are below the average number of laboratory activities recommended by the curriculum. About 53.6% of the instructors agreed that only up to 40% of the recommended laboratory activities are performed in the universities. In agreement with the instructor's response, 71.9% of the students agreed that the numbers of laboratory activities are 2 to 6 in each course. In general the finding of this study uncovered that there are few number of laboratory activities recommended in the manuals compared to the total number of laboratory activities recommended in the curriculum(156 of 438). All of the laboratory manuals are not published that are designed to have all the problem resolution tasks included in their content. Because this, the instructors either write laboratory exercises for their own use or omit the laboratory activity. From instructor's interview and open ended questions, among the various reasons lack of laboratory manuals was the major one. The instructors use laboratory manuals from internet sources which are not compatible with the existing laboratory settings and objectives set in the curriculum. Hence, most of the laboratory activities are omitted.

Students self evaluation showed that more than 51% of the students agreed and 24 % strongly agreed that they have the ability to perform the competencies and skills prescribed on the biology curriculum. About 25%, of the students disagreed or not sure about their ability to perform the competencies and skills prescribed on the biology curriculum of the old, the middle-aged and new universities respectively.

Kruskal-Wallis analysis of variance test with the age of the universities being the independent variable, indicates that there were no significant differences in participants' response on a scale of 1 (strongly disagree) to 5 (strongly agree). However, the actual laboratory performance skill test is low. Students' self evaluation about the acquisition of the competences set on the curriculum tends to be overestimated than the actual test results. This is probably that earned credits are a more objective, quantitative aspect, and perceived competence a more subjective, qualitative aspect of study success distinction in learning/performance goals (Kamphorst et al., 2013). The other probable reason is that the bias in self-evaluation may reflect self-protective or self-enhancement (Gramzow, et al., 2002).

The laboratory performance skill tests used in the study were identification of lab equipment (67.1%), function of laboratory equipment (58.36%), setting a microscope (26.09%), handling of microscope (22.82%), mounting of specimen on slide (21.64%), focusing from low to high power (19. 64%), staining specimen (18.73%), measuring weight in gm, mg and µg (8.64%), measuring liquid in liter, ml and µl (8.18%), drawing (4.44%) and estimation of the diameter of a microscope(0 %). Measuring is basic (lower order) science process skills but is low. The result of this study is different from those of Moni et al. (2007). The results of Moni et al.(2007), showed that students demonstrating proficient core laboratory skills on their first attempt for correct use of a micropipette, for preparation of dilutions using a micropipette, for correct use of a light microscope, and for proficient use of digital data.

The result of this study is in agreement with the results shown by Saha(2001) and Cushing (2002). Saha(2001) showed that students demonstrated more skill in performing than planning and reasoning and the students' performances at the item level were very poor for some items. Cushing (2002) studied that the mean score of microscope assessment and task assessment were low.

Balanay and Roa (2013**)** have conducted a study to assess the scientific skills of the selected second year students of high schools on their monitoring of the growth of string beans. The students were differ in their accuracy and precision in the measurement but moderately excellent in data collection and excellent in the setting up the equipment, following procedures, safety and precautions and clean up procedure. Microscopes are the most common source of technology, but were used almost exclusively for observations of teacher-determined objects, rather than as tools to increase the number of categories of science inquiry addressed (Basey et al.2000). There is a need, therefore, to use the available laboratory instruments more effectively and efficiently.

There was an assumption that students with better prior back ground in biology laboratory at secondary and preparatory schools would have higher biology laboratory performance test results than those without it but there was no significant correlation between high school lab back ground and laboratory skill performance test result. The result of this study supports that of Bone and Reid (2011).

Ochonogor (2011) stated that there is a significant difference in performance level among biology education undergraduates and between male and female biology education students in that the female students are more in biology education as a course and also perform significantly better than the males. However, in this study, there is no significant difference in laboratory practical performance level of male and female students. But the result of this study is in agreement with Jack (2013). A study conducted by Jack (2013), to find out the influence of selected variables, such as sex, on students' science process skills acquisition in Nigeria, revealed that sex, does not influence students' acquisition of science process skills.

Students' course achievement (GPA) is a significantly and a positively related with some of laboratory skill performance test scores, such as identification of lab equipment, handling of microscope, setting of microscope, estimation of diameter of field of vision, measuring liquid. The grade point average (GPA) was also significantly and positively related with higher education entrance exam score (p=0.009). This may be due to students academic back ground and individual differences.

There is no significant correlation between high school laboratory back ground and GPA. This may be due to the varied learning abilities of students in theory and practices. Moreover, correlation and multiple regression analyses revealed that students' laboratory performance skills is significantly positively correlated with higher education entrance exam score, availability of laboratory resources and teachers 'experiences. Teachers' experience have significant positive regression weights in agreement with Friedrichsen et al. (2009) in that teaching experience appear to lead to more integration among pedagogical knowledge components for students' achievement.

The mode of assessment directly influences teachers' teaching methods, students' learning styles and attitudes towards practical activities (Bekalo and Welford, 1999; Akinbobola and Afolabi, 2010). Although, performance assessments require more time to administer than do other forms of assessment, it is appropriate to evaluate students' laboratory skill performance. The unique challenges of skill assessment are transferability of skills, use of time constrains and the increased risk for test anxiety (Silvestrone, 2005).This study showed that practical methods of assessing students' performance need more attention.

A teacher who is not properly equipped with laboratory manipulative skills may experience difficulties to deliver these skills to his/her students. The results of this study support the work of Collis et al. (2008). They stated that there is a shortage of appropriately skilled graduates in some bioscience areas particularly with regard to graduates with laboratory skills. Richardson (2008) showed that the existence of significant relationship between teacher qualifications and student achievement. In agreement with that of Richardson (2008), in this study, instructors' manipulative skills and instructors' qualification are significantly and positively correlated with students' laboratory performance skills.

One of the factors which has led to a general reduction in the practical experience available to university students which has been found that low availability of chemicals and apparatus, an unavailability and less quality of the laboratory manuals and the increased number of students.

Achievement of the objectives of science practical work depends a lot on the mode of assessment of laboratory work adopted by the instructors and examination bodies Akinbobola and Afolabi, 2010). The mode of assessment directly influences teachers' teaching methods, students' learning styles and attitudes towards practical activities (Bekalo and Welford, 1999). This study showed that instructors do not use performance-based assessment to assess the students' biology laboratory skills due various reasons. More frequently, biology laboratory instructors use laboratory report, move and written exam. Among the reasons, the instructors believe that the move and written exam help them to assess the students' knowledge and skills. All the reasons raised by the instructors assess student's concept but not skills. This may be due to the instructors experience and background.

In laboratory move examination, specimens are usually displayed and students' would be able to write the name or category of the specimen. This is purely knowledge – based, simple recalling. The students are not expected to manipulate their skills.

Performance assessments require more time to administer than do other forms of assessment. The unique challenges of skill assessment are transferability of skills, use of time constrains and the increased risk for test anxiety (Silvestrone, 2005). Over all, this study showed that a practical method of assessing students' performance has received minimal attention.

Lee (1997) defined fieldwork as outdoor education. Fieldwork is the "application of knowledge and skills learnt in the classroom to environments outside the classroom" - and it takes many forms (Paterson, 2013). Goulder, Scott and Scott (2013) demonstrated that students who had the most positive perception of fieldwork also had a strongly positive view of laboratory work while other students had a less positive perception of both field and laboratory work.

Field trips groups had higher achievement as measured by quiz scores. College biology courses, such as ecology, biodiversity, conservation, zoology, etc could be enhanced by the inclusion of field trips. In this study survey from students demonstrated that about 90% of the students agreed that field trips help students to understand the real biological situations. However, as shown in table 21, about 92% of students agreed that the number of field trips conducted in the biology undergraduate program of the sample universities is three times. The number of field trips conducted in the universities varies from university to university, three times in the old and middle-aged universities and only ale field trip in the new university. Interviewed of department heads and instructors demonstrate that the main reason for this is due to awareness of the university management and lack of transport. In this study there was no correlation between students attitudes and the number of past field trip experiences.

Manipulating materials, measuring and using numbers and pre lab activities were common activities, and were found in every manual and in every university. However, students were rarely asked to plan, design and to communicate and interpret the results. The result of this study found to be in agreement with other studies carried out elsewhere (Saha, 2001). Saha(2001) showed that students demonstrate more skills in performing than planning and reasoning, and the students' performances at the item level were very poor for some items.

Findings of the seven categories of Laboratory Task Analysis Instrument used in this study has revealed that students were only required plan and design their experiments in a very few (3 out of 22) manuals. The integrated science process skills are very few (24.6%) as compared to the basic science process skills (75.4%). The result of this study found to be in agreement with other studies (Akinbobola and Afolabi, 2010; Basey et al., 2000; Germann et al., 1996; Tafa, 2012; Tweedy and Hoese, 2005). The study of Tafa (2012) showed that the majority of the activities have lower inquiry level of one and the dominant practical work identified was demonstration type activity. The percent of the integrated science process skills in this study is very less (24.6%) while Akinbobola and Afolabi's is 37.2%.

None of the manuals asked students to formulate questions and hypothesis, to identify independent variable, design their experiment and design data table. Basic science processes are vital for science learning and concept formation at the primary and junior secondary school levels. The more difficult and integrated science process skills are more appropriate at the secondary and tertiary school levels for the formation of models, experimenting and inferring (Akinbobola and Afolabi, 2010). However, the biology laboratory manuals in these universities are deficient in the integrated science process skills.

Reading is the most common pre-lab activity but observation and questions were rarely asked. The result is found to be in agreement with those of Germann, et al. (1996), Haskins (2000), Basey et al. (2000) and Tweedy and Hoese (2005). Pre - lab reading should lead to enhanced learning outcomes for students as well as better meeting ethical guidelines for instructors to design practical activities. Haskins (2000) conducted a study on determining whether the material found in ABC promotes scientific inquiry through the inclusion of science process skills and the type and character of laboratory activities in Columbia and found that all laboratory activities provide a pre-laboratory activities and most often skill of learning techniques and manipulating apparatus, and the least was student planning and designing. Similarly, Tweedy and Hoese (2005) conducted Laboratory Task Analysis Instrument of diffusion activities of two-year and four-year colleges in the United States. They found that most manuals did not include much inquiry, often failed to engage students in the planning and designing of the activities. In this study, manual analysis(Table 19) revealed that the laboratory experiments conducted in the universities were confirmatory rather than investigative experiments. Confirmatory experiments are planned by the teacher with the goal in mind of confirming the theoretical material studied in class and the students perform the experiments according to the teacher's instructions, then organize their results, analyze them, and draw conclusions (Katchevich et al, 2013). Like Basey et al. (2000), laboratory manuals were deficient in deriving problems/hypotheses, variables, methods, and extensions. Result from the analysis of the undergraduate biology laboratory manuals of this study revealed that a high percentage of basic science process skills in the laboratory as compared to the integrated science process skills. The finding is in agreement with that of the results of Ongowo and Indoshi (2013) in Kenya that a high percentage of basic science process skills as compared to the integrated science process skills in the practical examination questions.

In this study, the availability of biology laboratory equipment was positively and significantly related to students' laboratory skill performance test result. A similar study conducted to determine the available physics laboratory equipment and the extent of utilizing the available equipment for the learning -teaching of physics in senior secondary schools in Nigeria, demonstrated that science laboratory with adequate equipment is a critical variable in determining the quality of output from senior secondary school Physics(Olufunke, 2012).

5.3 *Conclusions of the Study*

Biology education plays a significant role in various areas of human development. To achieve this goal, universities need to evaluate the attainment of the intended objectives. The aim of this study was to assess the biology laboratory skill performance of undergraduate biology students in some Ethiopian universities. The study addressed that knowledge gap, the way to address the attainment of the objectives of biology laboratory skills in particular. The methodology and instruments used in this study will have great importance for the universities to evaluate the effectiveness of the laboratory works.

The study uncovered that students had low scores for biology laboratory practical skills. The results implicated a need for the universities to set standards for each practical skill, to design alternative assessment for biology laboratory practical skills, and to monitor students' progress during the whole undergraduate period in the acquisition of their laboratory practical skills.

The findings of the study will have great importance not only in these universities, but also in other universities, and not only in biology undergraduate laboratories, but also in other sciences, such as chemistry and physics. The findings of this study would also provide the universities with the opportunities to use time- and cost-effective laboratory teaching by assessing their students' laboratory performance skills and take intervention that would enable the students to be productive and contribute towards global excellence in their practical skills.

5.4 *Recommendation*

From the results of the analysis, the following recommendations are drawn:

- Educators should review the laboratory manuals that are available and implement changes that would promote the use of all scientific skills

- Standard harmonized laboratory manuals for each course should be developed by Ministry of Education which allows students the opportunity to engage in scientific thinking and participate in scientific inquiry.

- Educators should evaluate the laboratory manuals with an inventory such as the one derived in this paper, and attempt to address the seven categories Task Analysis in each laboratory course.

- In biology laboratory performance-based assessment needs to be undertaken in placement of to paper-and-pencil tests.

- Departments should stabilize systems to check the quality and quantity of laboratory practical activities and the mode of the assessments for the laboratory skills.

- Instructors need much more assistance and professional development of biology laboratory manipulative skills as well as pedagogies.

- The need for professional development of biology instructors on process skills is recommended to educate them on inquiry methods which promote acquisition of science process skills in biology laboratory.

- Biology departments in the universities should equip laboratories with the necessary chemicals and equipment, and also to provide useful materials and appropriate teaching aids to help reduce the problems of ill-equipped laboratories.

- The findings implicated that the Ministry of Education should foster secondary high schools and college preparatory schools to put greater efforts at preparing undergraduate admitted students for students' better outcome and their retention in universities.

- Further studies should be conducted to set minimum competency standards for each laboratory activities and in each course.

REFERENCES

AAAS (American Association for the Advancement of Science) (1993). *Benchmarks for scientific literacy: A Project 2061 report*. New York: Oxford University Press.

Abebe, B. (2013). Education Gaps responsible for Poor Graduate Employability. Addis Fortune, 14(689), Retrieved from http://www.addisfortune.com

Abraham, I. & Millar, R. (2008). Does Practical Work Really Work? A Study of the Effectiveness of Practical Work as a Teaching and Learning Method in School Science. *International Journal of Science Education*, 30 (14), 1945-1969.

Achor, E.E., Kurumeh, S.M. & Orokpo, C.A. (2012). Gender Dimension in Predictors of Students' Performance in MOCK-SSCE Practical and Theory Chemistry Examinations in Some Secondary Schools in Nigeria. *Education*, 2(2), 16-22 .DOI: 10.5923/j.edu.20120202.04

Adeyemi, T.O. (2008). Predicting Students' Performance in Senior Secondary Certificate Examinations from Performance in Junior Secondary Certificate Examinations in Ondo State, Nigeria. *Humanity and Social Sciences Journal,* 3 (1), 26-36

Aina, J. K.(2014). Student Learning of Physics in Colleges of Education: Analysis of Performances. *International Journal of Development Research*, 4 (11), 2409-2412.

Akanbi, A.O. & Usman, R.S. (2014). A Correlational Study of NCE Physics Students' Performances in Micro Teaching and Teaching Practice. *Journal of Education Research and Behavioral Sciences*, (2), 60-64.

Akinbobola, A.O. & Afolabi, F. (2010). Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria. *American-Eurasian Journal of Scientific Research*, 5 (4), 234-240.

Aladejama, F. & Aderibigbe, O. (2007). Science Laboratory Environment and Academic Performance. *Journal of Science Education and Technology*, 16, 500-506. DOI: 10.1007/s10956-007-9072-4

Amasuomo, J. O. (2015). Academic performance of Students during transition period before choice of disciplines in Nigeria Certificate in Education (Technical) programme. *Cypriot Journal of Educational Sciences,* 10 (3), 192-204

Ashford-Rowe, K., Herrington, J. & Brown. C. (2014). Establishing the Critical Elements that Determine Authentic Assessment. *Assessment and Evaluation in Higher* Education, 39(2), 205-222. DOI: 10.1080/02602938.2013.819566

Balanay,C.A.S &Roa, E.C.(2013). Assessment on Students' Science Process Skills: A Student- Centered Approach. *International Journal of Biology Education*, 3(1), 26-40. www.ijobed.com

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and Children*, 46 (2), 26-29.

Basey, J. M., Mendelow, T. N. & Ramos, C. N. (2000). Current Trends of Community College Laboratory Curricula in Biology: An Analysis of Inquiry, Technology, and Content. *Journal of Biological Education*, 34 (2), 80-86.

Bekalo, S. A. & Welford, A. G. (1999). Secondary Pre-service Teacher Education in Ethiopia: Its Impact on Teachers' Competence and Confidence to Teach Practical Work in Science. *International Journal of Science Education*, 21(12), 1293-1310.

Blanchard, M.R., Southerland, S.A., Osborne, J.W., Sampson, V.D., Annetta, L.A., & Granger, E.M. (2010). Is Inquiry Possible in Light of Accountability? A Quantitative Comparison of the Relative Effectiveness of Guided Inquiry and Verification Laboratory Instruction. *Science Education*, 94(4), 577-616.

Blosser, P.E. (1990). The Role of the Laboratory in Science Teaching**.** *Research Matters - to the Science Teacher*, From *https://www.narst.org/publications/research/labs.cfm*

Bone, E.K. & Reid, R.J. (2011). Prior Learning in Biology at High School does not Predict Performance in the FIrst Year at University. *Higher Education Research and Development*, 30 (6), 709-724. DOI: 10.1080/07294360.2010.539599

Boyle A, Maguire S, Martin A, Milsom C, Nash R, Rawlinson S, Turner A, Wurthmann S & Conchie S (2007). Fieldwork is Good: The Student Perception and the Affective Domain. *Journal of Geography in Higher Education*, 31(2), 299-317.

Chabalengula,V. M., Mumba, F., Hunter, W. F. J. & Wilso, E. (2009). A Model for Assessing Students' Science Process Skills during Science LaboratoryWork. *Problems of Education in the 21st Century*, 11, 28-36.

Clark, L.R. (2011). *Examining the Relation between High School Science Coursework and Performance in College Chemistry* (Doctoral Dissertation). Retrieved from https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/11966/clark_lakisha_rhea_phd2011su.pdf?sequence=1

Clotfelter, C.T., Ladd, H.F. & Vigdor, J.L. (2007). How and why do Teacher Credentials Matter or Student Achievement? (Working Paper No. 2). From National Center for Analysis of Longitudinal Data in Education Research, http://www.caldercenter.org/sites/default/files/1001058.

Collis, M., Gibson, A., Hughes, I., Sayers, G. & Todd, M. (2008). The Student View of 1st year Laboratory Work in the Biosciences – Score Gamma? *Bioscience Education e-journal*, *www.bioscience.heacademy.ac.uk/journal/vol11/beej-11-2.pdf*

Cotton, D.E. & Cotton, P.A**.** (2009). Field biology experiences of undergraduate students: the impact of novelty space. *Journal of Biological Education*, 43 (4), 169-174.

Craw, K.G. (2009). *Performance Assessment Practices: A Case Study of Science Teachers in a Suburban High School Setting (*Doctoral dissertation). Available from ProQuest Dissertations and Thesis Database. (UMI Number: 3368395)

Cushing, P. R. (2002). *A comparative analysis of multiple choice and Student Performance –Task Assessment in the high school biology class room (*Doctoral dissertation). Available from ProQuest Dissertations and Thesis Database. (UMI Number: 3052872)

Dahar, M.A. & Faize, F.A. (2011). Effect of the availability and the use of Science laboratories on Academic Achievement of Students in Punjab (Pakistan). *European Journal of Scientific Research*, 15(2), 193-202.

Darling, N., Caldwell, L. L., & Smith, R. (2005). Participation in School-Based Extracurricular Activities and Adolescent Adjustment. *Journal of Leisure Research*, 37 (1), 51-76.

Dial, J.C. (2000). *The Effect of Teacher Experience and Teacher Degree Levels on Student Achievement in Mathematics and Communication Arts (D*octoral dissertation). Retrieved from https://www.bakeru.edu/images/pdf/SOE/EdD_Theses/Dial_Jaime.pdf

Domin, D.S (1999). A Content Analysis of General Chemistry Laboratory Manuals for Evidence of Higher-order Cognitive Tasks. *Journal of Chemical Education*, 76 (1), 109-112.

Domin, D. S. (2007). Students' Perceptions of when Conceptual Development Occurs During Laboratory Instruction. *Chemistry Education Research and Practice*, 8 (2), 140-152.

Easton, E. & Gilburn, A. (2012). The Field Course Effect: Gains in Cognitive Learning in Undergraduate Biology Students Following a Field Course. *Journal of Biological Education*, 46 (1), 29-35.

El-Mowafy, A. (2014). Using Peer Assessment of Fieldwork to Enhance Students' Practical Training. *Assessment and Evaluation in Higher Education*, 39 (2), 223-241.

Ergül, R., Simsekli, Y., Çalis, S., Özdilek, Z., Göçmençeleb, S. & Sanli , M. (2011). The Effects of Inquiry-based Science Teaching on Elementary School Students' Science Process Skills and Science Attitudes. *Bulgarian Journal of Science and Education Policy,* 5 (1), 48-68.

Falicoff, C.B., Castiñeiras, J.M.D. & Odetti, H.S. (2014). Science Competency of Argentinian University Students in the First Year of Biochemistry and Biotechnology Courses. *Problems of Education in the 21Stcentury* (62), 29-39.

Federal Democratic Republic of Ethiopia (1994). *Education and Training policy*. (St. George publisher), Addis Ababa, Ethiopia

Feyzioğlu, B. (2009). An Investigation of the Relationship between Science Process Skills with Efficient Laboratory Use and Science Achievement in Chemistry Education. *Journal of Turkish Science Education*, 6 (3), 114-132.

Fitch, G.K.(2007). A Rubric for Assessing a Students' Ability to Use the Light Microscope. *The American Biology Teacher*, 69 (4), 211-214.

Friedrichsen, P. J. Abell, S. K., Pareja, E. M., Patrick L. Brown,P.L, Lankford, D. M. & Volkmann, M.J.(2009). Does Teaching Experience Matter? Examining Biology Teachers' Prior Knowledge for Teaching in an Alternative Certification Program. *Journal of Research in Science Teaching*, 46 (4), 357-383.

Galiher, S. (2006). *Understanding the effect of extracurricular involvement*. A Research Project Report M.Ed., Indiana University, South Bend. http://www.cscanada.org

Gardiner, P.G. Farragher, P. (1999). The Quantity and Quality of Biology Laboratory Work in British Columbia High Schools. *School Science and Mathematics* , 99 (4), 197-204.

Gauchet, C. (2011). *Effects of a novel science curriculum versus tradition science curriculum on problem solving skills and attitudes for 10th grade students (*Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses database. (UMI number:3413101)

Geiser, S., & Santelices, V. M. (2007). Validity of High School Grades in Predicting Student Success beyond the Freshman Year. Research and Occasional Paper Series: CSHE.6.07.Retrieved from http://cshe.berkeley.edu/publications/docs/ROPS.GEISER SAT 6.12.07.pdf

Genovese J.E.C. (2004). The ten percent solution: anatomy of an education myth. *Skeptic* (*Altadena*), 55 (3), 1-3.

Germann, P. J., Haskins, S. & Auls, S. (1996). Analysis of Nine High School Biology Laboratory Manuals: Promoting Scientific Inquiry. J*ournal of Research in Science Teaching* , 33 (5), 475-499.

Golafshani, N. (2003). Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report,* 8 (4), 597-607. Available at http://www.nova.edu/ssss/QR/QR8-4/golafshani.pdf

Goulder, R., Scott, G.W. and Scott, L.J. (2013). Students' Perception of Biology Fieldwork: The Example of Students Undertaking a Preliminary Year at a UK University. *International Journal of Science Education*, 35 (8), 1385-1406.

Gramzow, R.H., Elliot, A.J., Asher, E. & McGregor, H.A. (2002).Self-evaluation Bias and Academic Performance: Some Ways and Some Reasons Why. *Journal of Research in Personality*, 37, 41-61.

Haider, S. Z. and Hussain, A. (2014). Relationship between Teacher Factors and Student Achievement: A Correlational Study of Secondary Schools. *US-China Education Review A*, 4 (7), 465-480

Hammann, M., Phan, T.H., Ehmer, M. & Grimm, T. (2008). Assessing Pupils' Skills in Experimentation. *Journal of Biological Education*, 42 (2), 66-72.

Hansen, J. B. (2000), Student Performance and Student Growth as measure of success: A evaluator's perspective. Paper presented at annual meeting of the American Educational Research Association New Orleans, Louisiana, April 25, 2000

Harmonized Curriculum for BSc Degree Program in Biology (2009), Addis Ababa, Ethiopia (unpublished), 3-5

Harris, K-L., Krause, K., Gleeson, D., Peat, M., Taylor, C. & Garnett, R. (2007). *Enhancing Assessment in the Biological Sciences: Ideas and resources for university educators*. Available at: www.bioassess.edu.au

Haskins, S. (2000). *An analysis of Laboratory Activities found in Applications in Biology/Chemistry: A contextual approach to Laboratory Science (ABC)(D*octoral dissertation). Available from Bell and Howell information and learning database. (UMI number: 9999294)

Heyborne, W.H. Clarke,J.A. & Perrett, J.J (2011). A Comparison of Two Forms of Assessment in an Introductory Biology Laboratory Course. *Journal of College Science Teaching*, 40 (5), 28-31.

Hofstein, A.(2004). The Laboratory in Chemistry Education: Thirty years of Experience with Developments, Implementation, and Research. *Chemistry Education Research and Practice*, 5 (3), 247-264.

Hofstein, A., & Lunetta, V.N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education,* 88 (1), 28-54.

Hofstein, A. & Mamlok-Naaman, R. (2007). The Laboratory in Science Education: The State of the Art. *Chemistry Education Research and Practice,* 8 (2), 105-107.

Hughes, C.(2013). A Case Study of Assessment of Graduate Learning Outcomes at the Program, Course and Task Level. *Assessment and Evaluation in Higher Education,* 38 (4), 492-506.

Hunt, L., Koender, A. & Gynnild, V. (2012). Assessing Practical Laboratory Skills in Undergraduate Molecular Biology Courses. *Assessment and Evaluation in Higher Education,* 37 (7), 861-874.

Jack, G.U. (2013). The Influence of Identified Student and School Variables on Students' Science Process Skills Acquisition. *Journal of Education and Practice,* 4 (5), 16-22.

Kamal, A. A. & Muideen, R. G. (2014). Relationship between Teacher's Attitude and Student's Academic Achievement in Senior Secondary School Chemistry. A case Study of Ijebu-Ode and Odogbolu Local Government Area of Ogun State. *Wudpecker Journal of Educational Research*, 3 (3), 35- 43.

Kamphorst, J. C., Hofman, W.H.A., Jansen, E.P.W.A. & Terlouw, C. (2013). The Relationship Between Perceived Competence and Earned Credits in Competence Based Higher Education. *Assessment and Evaluation in Higher Education,* 38 (6), 646-661. DOI: 10.1080/02602938.2012.680015

Kampourakis, C. & Tsaparlis, G. (2003). Effect of a Practical Activity on Problem Solving. *Chemistry Education: Research and Practice,* 4 (3), 319-333.

Karemera, D., Reuben, L. J., & Sillah, M. R. (2003). The Effects of Academic Environment and Background Characteristics on Student Satisfaction and Performance: The Case of South Carolina State University's School of Business. *College Student Journal*, 37,298-308.

Katchevich, D., Hofstein, A. & Mamlok-Naaman, R. (2013). Argumentation in the Chemistry Laboratory: Inquiry and Confirmatory Experiments. *Research in Science Education,* 43, 317-345.

Kolb, D.A. (1984). *Experiential Learning: Experience as the source of learning and development*, New Jersey: Prentice-Hall, pp 41-45.

Kuddus, R.H. (2013). Who Should Change Biology Education: An Analysis of the Final Report on the Vision and Change in Undergraduate Biology Education Conference. *International Journal of Biology Education*, 3 (1), 63-835.

Lee, S. (1997). *Assessment of effect of field trips on students' achievement and Attitudes towards Field trips in College Biology (D*octoral dissertation). Available from Bell and Howell information and learning database. (UMI number: 9729066)

Lee, S.W.Y., Lai, Y.C., Yu, H. T. A & Lin, Y.T.K. (2012). Impact of Biology Laboratory Courses on Students' Science Performance and Views about Laboratory Courses in General: Innovative Measurements and Analyses. *Journal of Biological Education,* 46 (3), 173-179. DOI: 10.1080/00219266.2011.634017

Lewis, J. (2006). Bringing the Real World into the Biology Curriculum. *Journal of Biological Education,* 40 (3), 101-106. DOI: 10.1080/00219266.2006.9656025

Liu, O.L., Lee, H. & Linn, M.C.(2010). An Investigation of Teacher Impact on Student Inquiry Science Performance Using a Hierarchical Linear Model. *Journal of Research in Science Teaching,* 47 (7), 807-819.

Loehr , J. F., Almarode , J.T., Tai, R.H. & Sadler, P.M. (2012). High School and College Biology: A Multi-Level Model of The Effects of High School Courses on Introductory Course Performance. *Journal of Biological Education*, 46 (3), 165-172, DOI: 10.1080/00219266.2011.617767

Luketic, C.D. & Dolan, E.L. (2013). Factors Influencing Student Perceptions of High-School Science Laboratory Environments. *Learning Environments Research,* 16 (1), 37-47.

Lunetta, V. N., Hofstein, A. & Clough, M., (2007). Learning and Teaching in the School Science Laboratory: An Analysis of Research, Theory, and Practice, in N, Lederman and S. Abel (Eds,), *Handbook of Research on Science Education(*pp. 393-441). Mahwah, NJ: Lawrence Erlbaum.

Madden, D. (2009). *Educational Techniques that Foster Creative Solutions and Good Data in Field Biology: Examples from 3 Continents* (Doctoral dissertation). Retrieved from http://uir.unisa.ac.za/bitstream/handle/10500/1200/thesis.pdf

Menjo, E. (2013). An Assessment of Effectiveness of the Secondary school Science Pedagogy and Curriculum Relevance to Students' Needs in Baringo Central, Kenya. *Journal of Emerging Trends in Educational Research and Policy Studies,* 4 (3), 433-441.

Millar, R., Tiberghien, A. & Marechal J. L. (2002). The Varieties of Laboratory Work: A Way of Profiling Labwork Tasks. In D. Psillos and H. Niedderer (eds), *The Teaching and Learning in the Science Laborator*y (pp. 9-20). Kluwer Academic Publishers, Netherlands.

Moni , R.W., Hryciw, D.H., Poronnik, P., Lluka, L.J. & Moni,K.B.(2007). Assessing Core Manipulative Skills in a Large, First-Year Laboratory. *Advances in Physiology Education,* 31, 266-269.

National Agency for Examination (2013). http://www.nae.gov.et/ Public/ ViewPlacementResult.aspx

National Committee on Science Education Standards and Assessment (1993). *National Science Education Standards: An Enhancement Sampler*. Washington, DC: National Research Council.

National Educational Assessment and Examinations Agency**,** FDRE (2013). Forth National Learning Assessment on Grades 4 And 8 Students. Addis Ababa, Ethiopia. January 2013

Nawaz, N. Mahmood, N. & Rana, R.K. (2004). Relationship between Post-Graduate Science Students' Achievment in Theory and Practical Examination: A dimension to Assess Quality of Higher Education. *Bulletin of Education and Research*, 26 (1), 41-47.

Noble, J. & Radunzel, J. (2007). *College readiness = college success beyond the first year.* Paper presented at the Annual Forum of the Association for Institutional Research, June 2-6, Kansas City, MO.

Nundy, S. (1999). The Fieldwork Effect: The Role and Impact of Fieldwork in the Upper Primary School. *International Research in Geographical and Environmental Education,* 8 (2), 190-198.

Nunnery, J., Kaplan, L., Owings, W. A. & Pribesh, S. (2009). The Effects of Troops to Teachers on Student Achievement: One State's Study. *NASSP Bulletin*, 93 (4), 249-272.

Ochonogor, C.E. (2011). Performance Analysis of Science Education Undergraduates: A Case Study of Biology Education Students, *US-China Education Review A*, 5, 682-690.

Olufunke, B. T. (2012). Effect of Availability and Utilization of Physics Laboratory Equipment on Students' Academic Achievement in Senior Secondary School Physics. *World Journal of Education,* 2 (5), 1-7, www.sciedu.ca/wje

Ongowo, R.O. & Indoshi, F. C. (2013). Science Process Skills in the Kenya Certificate of Secondary Education Biology Practical Examinations. *Creative Education,* 4 (11), 713-717.

Ottander, C. & Grelsson, G. (2006). Laboratory work: The Teachers' Perspective. *Journal of Biological Education*, 40 (3), 113-118.

Özgelen, S.(2012). Students' Science Process Skills within a Cognitive Domain Framework. *Eurasia Journal of Mathematics, Science and Technology Education,* 8 (4), 283-292

Paterson, P. (2013). Using Technology to Develop More Efficient Teacher-Friendly Fieldwork Process. *Interaction*, 41 (1), 9-12.

Pešaković, D., Flogie, A. & Aberšek, B. (2014). Development and Evaluation of a Competence-Based Teaching Process for Science and Technology Education. *Journal of Baltic Science Education*, 13 (5), 740-755.

Peters, C.J. (2006). *An Assessment Template for Introductory College Biological Laboratory Manuals (D*octoral dissertation). Available from ProQuest dissertation and Thesis database. (UMI Number: 3233946)

Rayner, P. & Ashcroft, K. (2011). Ethiopian Higher Education: Expansion, Dilemmas and Quality.*ARCHIVE, http://WENR.WES.ORG/2011/06/WENR-JUNE-2011-FEATURE/*

Rice, J.K. (2010). The Impact of Teacher Experience: Examining the Evidence and Policy Implications. *National Center for Analysis of Longitudinal Data in Education Research*, http://www.urban.org

Richardson, A. R. (2008). *An Examination of Teacher Qualifications and Student Achievement in Mathematics (D*octoral dissertation). Retrieved from https://etd.auburn.edu/bitstream/handle/10415/1181/Richardson_Antoine_8.pdf?sequence=1&ts=1449298994642

Rickinson, M., Dillon, J., Teamey, K., Morris, M., Choi, M. Y., Sanders, D. & Benefield, P. (2004). *A review of Research on Outdoor Learning*. FSC occasional publication 87. Shrewsbury: Field Studies Council.

Royal Society of Biology (2010, December). *The Importance of Practical Biology: from School to Higher Education.* Retrieved from https://www.rsb.org.uk/images/Practical%20Biology%20Position%20Paper.pdf

Sabri, K.S. & Emuas, A.M. (1999). The Relationship between School Laboratory Experiments and Academic Achievement of Palestinian Students in Introductory University Science Courses. *Research in Post-Compulsory Education*, 4 (1), 87-96.

Sadler, P.M. & Tai, R.H. (2001). Success in Introductory College Physics: The Role of High School Preparation. *Science Education*, 85, 111-136.

Saha, G.S. (2001). *Implementing the Science Assessment Standards: Developing and validating a Set of Laboratory Assessment Tasks in High School Biology* (Doctoral dissertation). Available from Bell and Howell information and learning database. (UMI number: 9997996)

Sawyer, R. (2008). Benefits of Additional High School Course Work and Improved Course Performance in Preparing Students for College. *ACT Research Report Series* 2008-1.

Scott, G.W., Goulder, R., Wheeler, P., Scott, L.J. Tobin, M.L.& Marsham, S. (2012). The Value of Fieldwork in Life and Environmental Sciences in the Context of Higher Education: A Case Study in Learning about Biodiversity. *Journal of Science Education and Technology*, 21, 11-21.

Shavelson, R. J., Baxter, G.P. & Pine J. (1991). Performance assessment in science. *Applied Measurement in Education*, 4 (4), 347-362.

Sheeba, M.N. (2013). An Anatomy of Science Process Skills in The Light of the Challenges to Realize Science Instruction Leading to Global Excellence in Education. *Educationia Confab*, 2 (4), 108-113.

Silvestrone, J.M. (2005). Performance-Based Assessment: Improving the Value of Laboratory and Skills Examinations. *New Directions for Teaching and Learning*, 100, 65-71.

Simon, M.K.(2011). *Dissertation and Scholarly Research: Recipes your Success* (2011 ed). Seattle, WA: Dissertation Success, LLC. http://dissertationrecipes.com/

Slater, T.F. & Ryan, J.M. (1993). Laboratory Performance Assessment. *The Physics Teacher, 31*, 306 -308.

Smith, D. (2004). Issues and Trends in Higher Education Biology Fieldwork. *Journal of Biological Education*, 39 (1), 6-10.

Sundberg ,M. .D & Moncada, G. J. (1994). Creating Effective Investigative Laboratories for Undergraduates. *BioScience*, 44 (10), 698-704.

Tafa, B. (2012) Laboratory Activities and Students Practical Performance: The Case of Practical Organic Chemistry I Course of Haramaya University. *African Journal of Science Education,* 2 (3), 47-76.

Tai, R.H., Sadler, P.M. & Loehr, J.F.(2005).Factors Influencing Success in Introductory College Chemistry. *Journal of Research in Science Teaching,* 42, (9), 987-1012

Tal, T., Alon, N.L. & Morag, O. (2014). Exemplary Practices in Field Trips to Natural Environments. *Journal of Research in Science Teaching*, 51 (4), 430-461.

Tamir, P. and Lunetta, V.N. (1978). An Analysis of Laboratory Inquiries in the BSCS Yellow Version. *The American Biology Teacher*, 353-357.

Tamir, P., Doran, R.L. & Kojima, S. (1992). Procedures Used in Practical Skills in Science. *Studies in Educational Evaluation,* 18, 277-290.

Tan, S. (2009). Misuses of KR-20 and Cronbach's Alpha Reliability Coefficients. *Education and Science*, 34 (152), 104-112.

Tarhana, L. & Sesen , B.A.(2010*).* Investigation the Effectiveness of Laboratory Works Related to "Acids and Bases" On Learning Achievements and Attitudes toward Laboratory. *Procedia Social and Behavioral Sciences*, 2, 2631-2636.

Tarrant, T.M. (2005). *Construction, Implementation, and evaluation of an undergraduate Biology Laboratory Teaching model* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI number: 3204806)

Tessier, J. (2010). An Inquiry-Based Biology Laboratory Improves Pre-service Elementary Teachers' Attitudes about Science. *Journal of College Science Teaching*, 84-90.

Tobin, K.G. (1990). Research on Science Laboratory Activities: In Pursuit of Better Questions and Answers to Improve Learning. *School Science and Mathematics,* 90, 403-418.

Trapani, G. & Clarke, F. (2012). Biotechniques Laboratory: An Enabling Course in the Biological Sciences. Biochemistry and Molecular Biology Education, 40 (1), 29-36.

Turiman, P., Omar, J., Daud, A. M. & Osman, K. (2011). Fostering the 21st Century Skills through Scientific Literacy and Science Process Skills. *Procedia - Social and Behavioral Sciences*, 59, 110-116.

Tweedy, M.E. & Hoese, W.J (2005) Diffusion Activities in College Laboratory Manuals, *Journal of Biological Education*, 39 (4), 150-155.

Urda, J. & Ramocki, S.P. (2015) Assessing students' performance by measured patterns of perceived strengths: does preference make a difference? *Assessment and Evaluation in Higher Education,* 40 (1), 33-44, DOI: 10.1080/02602938.2014.884536

Uwaifo, V.O. (2012). A Comparative Study of Students Performance in Technology based Theory and Practical Subjects in Nigerian Universities. *International Journal of Scientific and Technology Research*, 1(1), 1-3

Wambugu, P. W. & Changeiywo , J. M.(2008). Effects of Mastery Learning Approach on Secondary School Students' Physics Achievement. *Eurasia Journal of Mathematics, Science and Technology Education,* 4 (3), 293-302.

Wang, L.(2009). Educational Background and High School Maths Teachers' Specialism. *International Journal of Modern Education and Computer Science,* 1, 28-34

Whelan, B., B. Oliver, L. Hunt, S. Hammer, S. Jones, & A. Pearce. (2010). Capturing Stakeholder Perceptions of Graduate Capability Development: Challenges Associated With Graduate Employability Indicators. In Work-Integrated Learning – Responding to Challenges: Proceedings of the 2010 ACEN National Conference, September 29–October 1, 2010, Perth, ed. M. Campbell, 498–506. Australian Collaborative Education Network (ACEN) Inc.

Wolfe, B.A. & Martin, T.C. (2013). Design and Components of a Two-year College Interdisciplinary Field-study Course. *Journal of College Science Teaching***,** 43 (1), 16-28.

Wood, E. (2004). Why offer final year projects? Higher Education Academy Centre for Bioscience Conference - Making the Most of Final Year Projects: ftp://www.bioscience.heacademy.ac.uk/events/cardiff/wood.pdf (accessed May 2008)

Yadav, B. & Mishra, S.K. (2013). A Study of the Impact of Laboratory Approach on Achievement and Process Skills in Science among Is Standard Students. *International Journal of Scientific and Research Publications*, 3 (1), 1-6: www.ijsrp.org

Yildiz, A., Akpinar, E., Aydogdu, B. and Ergin, O. (2006). Science Teachers' Attitudes Aims of the Science Experiments. J*ournal of Turkish Science Education,* 3 (2), 1-6

Yizengaw, T. (2005). Policy development in higher education in Ethiopia and the role of donors and development partners, Paper presented at the International Expert Meeting-"Formulas that work: Making Higher education Support More effective; The Hague, The Netherlands, 23-24, May, 2005

Zhang, D. (2008).*The Effects of Teacher Education Level, Teaching Experience, And Teaching Behaviors on Student Science Achievement* (Doctoral dissertation). All Graduate Theses and Dissertations. Paper 155. http://digitalcommons.usu.edu/etd/155

APPENDIX

Appendix A: Rubric for biology laboratory practical skill performance test

I. MATERIALS

1. For identification of the basic(common) laboratory equipment

A. Autoclave coded 003

B. Bunsen burner coded 008

C. Centrifuge coded 004

D. Erlenmeyer flask coded 001

E. Mortar and pestle coded 010

F. Petri dish coded 002

G. Dissection kit coded 005

H. Funnels coded 009

I. Incubator coded 006

J. Forceps coded 007

2. For the use of the light microscope

A. Light microscope

B. Microscope slides

C. Cover slip

D. Water

E. Droppers

F. Forceps

G. Iodine solution

H. Methyl blue

I. Onion

J. Plastic ruler (Graph paper)

K. Scissors

3. For measuring weights and volumes

A. Triple Beam Balance

B. Electronic Balance

C. Micro pipette and tips

D. Graduating cylinder

E. Pipette

F. Beaker 750ml

II. INSTRUCTIONS FOR STUDENTS' ACTIVITIES

Code ____________________*Sex*_________*CGPA*__________

Instruction 1

There are coded apparatus in front of you. Select the function of the apparatus from column "B", and match to its name to column "A" and write the code number and the letter of corresponding function in the space provided.

Column A List of apparatuses	Code number and function		Column B Function of apparatuse
Autoclave	______	______	A. For grinding chemicals, plants, etc
Bunsen burner	______	______	B. Used to grow micro-organisms
Centrifuge	______	_____	C. Gas burner used to heat things
Forceps	_____	_____	D. Separates materials of varying density
Mortar and pestle	______	______	E. Holds or pick up small objects
Petri dish	______	______	F. used to keep a particular specimen at the ideal temperature or level of humidity for the appropriate analysis or manipulation
Dissection kit	______	______	G. Used to mix reagents, heating and preparation of microbial culture
Funnels	_______	______	H. used to dissect small animals
Incubator	______	_____	I. used to sterilize materials
Erlenmeyer flask	______	_____	J. pour liquids from one container to another or for filtering when equipped with filter paper

Instruction 2

a. Take the microscope

b. Take peal of epidermal tissue of an onion

c. Prepare wet mount slide and apply staining techniques

d. Observe your specimen under low, medium and high power magnification

e. Estimate the diameter of the field of view in medium power of your microscope and calculate the length of one onion epidermal cell

Instruction 3

Measure accurately the following substances using appropriate instrument.

A. ½ liter of water

B. 2 ml of water

C. 200µl of water

D. 50 g of salt

E. 1 mg of salt

F. 500µg of salt

III. RUBRIC FOR THE RATERS

1. The Use of the Light Microscope

Code ____________________________

	Practical skill	Performance level			
		4 points	3 points	2 points	1 point
1	Handling of the microscope	Students correctly place the microscope , handle slides , clean slides and uses cover slip	Student correctly performs 3 out of 4 steps	Student correctly performs 2 out of 4 steps	Student correctly performs 1 out of 4 steps
2	Setting the microscope for use	Switch on the light, adjusting the light , cleaning the slide	Switch on the light, adjusting the light	Switch on the light	Unable to switch the light
3	Mounting (dry, wet and permanent mount)	Handle the slide and cover slip at the edges, prepare the specimen accurately with in 2 minute	Handle slides and cover slip incorrectly but prepare the specimen accurately within 2 minutes	Handle slides and cover slip incorrectly and prepare the specimen With difficulty	Handle slides and cover slip incorrectly and not prepare the specimen accurately
4	Use of appropriate staining	Choose the correct staining(Iodine solution), applying it properly	Choose the correct staining but not applying it properly	Choose the correct staining only	Not choosing the correct staining
5	Focusing with low, high power and oil immersion objectives	Student uses stage clips to mount slide, adjusts eye pieces, focuses using lowest magnification and coarse focus before moving to fine focus and higher magnification	Student correctly performs 3 out of 4 steps in the sequence	Student correctly performs 2 out of 4 steps in the sequence	Student correctly performs 1 out of 4 steps in the sequence

6	Determining the diameter of the field of view and calculating the size of the cell	Follow the procedure, estimate the diameter of the field of vision (1500µm), Calculate the size of the onion epidermal cell.	Follow the procedure, estimate the diameter of the field of vision (1500µm), but unable to calculate the size of the onion epidermal cell	Follow the procedure, but unable to estimate the diameter of the field of vision and to calculate the size of the onion epidermal cell	Unable to follow the procedure, to estimate the diameter of the field of vision and to calculate the size of the onion epidermal cell

2. Measuring Weight and Volume

Code ______________

	Performance level	4	3	2	1	0
1	Ability to measure liquid substance in liter, ml, and micro liter using graduating cylinder, pipettes and micropipette	Able to choose the three measuring instruments and accurately measures each	Able to choose the three measuring instruments and inaccurately measures each	Able to choose the two measuring instruments and accurately measures each	Able to choose the one measuring instruments and accurately measures it	Unable to choose the three measuring instruments
2	Ability to weight dry substance in grams, milligrams and micrograms using beam balance and microbalance	Able to choose the two measuring instruments and accurately measures each	Able to choose the two measuring instruments and inaccurately measures each	Able to choose the one measuring instruments and accurately measure each	Able to choose the one measuring instruments and inaccurately measure it	Unable to choose the two measuring instruments

Appendix B: Laboratory Manual Evaluation Form

Description of evaluation criteria	Number of Activities in Each Course															
	Intr. to Biological Lab.T ech.	Phycology	Bryophyte s and Pteridophy	Seed	Invertebrat e Zoology	Vertebrate Zoology	Cell	Mycology	Research Methods	General Entomolog	Principles of	Principles of	General Microbiol	Plant Physiolog	Applied Entomolog
1 **PRE-LAB ACTIVITY** a. Reading																
b. Questions																
c. *Observations*																
2. **PLANNING AND DESIGN** *a. Formulates question/problem*																
b. Formulates hypothesis																
c. Identifies independent variable																
d. Identifies dependent variable																
e. Identifies constant variables																
f. Experimental control																
g. Designs observations																
h. Designs experiments																
i. Designs data table																
j. Predicts experimental results.																
3. MEASURING AND USING NUMBERS a. *Identify the measurement required.*																
b. *Specify the instrument to be used.*																
c. Choosing and using standard unit																
d. Add up the total measurement																
e. Recording unit correctly																
f. Comparing time, distance, area and volume with relevant units																

4.MANIPULATE MATERIALS, *a. Using and handling science apparatus*															
b. Maintaining science apparatus correctly and safely															
c. Cleaning science apparatus correctly															
d. Handling specimen correctly and carefully															
e. Sketch specimen and science apparatus															
5. RECORD RESULTS, MAKE QUALITATIVE AND QUANTITATIVE RELATIONSHIPS															
a. Recording information from investigations															
b. Results summarized in a table															
c. Graphs data															
d . Determines qualitative relationships															
e. Determines quantitative relationships															
F . Determines accuracy of experimental data															
6.DRAW CONCLUSIONS, MAKE INFERENCES AND GENERALIZATIONS a. Draws conclusions															
b. *Provides evidence*															
c. Discusses limitations/assumptions															
d. Formulates generalization/ model															
e. Makes inferences															
7.COMMUNICATE AND INTERPRET THE RESULTS **a.** *Express ideas or meanings*															
b. Drawing and making notes															
c. Writing experiment report to enable others to repeat the experiment															
d. Using references															

Appendix C: Questionnaire for Students

This study, "**An assessment of the state practical biology skills of undergraduate students in Ethiopian universities and the impact on their performance**", is a dissertation conducted in partial fulfillment of the requirements for the degree of Doctor of philosophy in Life Science Education at Institute for Science and Technology Education, University of South Africa.

The questionnaire asks you about your study habits, your learning skills, and your motivation for work in undergraduate biology skill performance. THERE IS NO RIGHT OR WRONG ANSWER TO THIS QUESTIONNAIRE. **THIS IS NOT A TEST**. We want you to respond to the questionnaire as accurately as possible, reflecting your own attitudes, observation and behaviors in learning biology laboratory practical.

I am kindly requesting your participation. In order to keep your confidentiality as a participant of the survey, I would like to clarify that:

- Your response to the survey is totally voluntary
- Your academic achievement will not be affected by resusal to participate or by withdrawing from the study.
- Results will be reported either in aggregate or without institutional or individual names (or other forms of identification)
- Respondents will receive a confidential summary of results upon a written request
- Responses to the survey will be kept confidential and secure, which means that the information will be coded and kept in a secure server and only the main researcher will be able to access such information.

I greatly appreciate your participation.

Sincerely,

Getachew Fetahi Gobaw

Ambo University

Email: getachewfetahi@yahoo.com

P.O.BOX: Ambo university post office 05

General Instruction: Please check the category that is most appropriate and put "√" mark in the box. If blank spaces are provided, write your answers in the spaces provided.

I. Demographic Data :

1. Gender Male ☐ male ☐

2. Higher Education Entrance examination score ________

3. GPA _________________________

4. Your back ground of laboratory practice in your secondary and preparatory schools:

Very poor ☐

Poor ☐

Good ☐

Very Good ☐

Excellent ☐

II. Attitude question regarding the biology laboratory Practical Activities

Please indicate your answer by putting a tick mark (√) in the column of your best choice

Q. No.	Description	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
5	The time given for each biology laboratory sessions was enough					
6	The biology laboratory practical activities were very important my to future career					
7	The biology laboratory practical activities are interesting.					
8	Field trips help students to understand the real situations.					
9	The biology laboratory practical activities are helpful for better understanding of the subjects.					
10	The biology laboratory practical activities are helpful to improve my grade.					
11	The biology laboratory practical activities are helpful to improve the concepts of the material covered in the lecture.					
12	Practical skill examination is better than paper and pencil examination or move examination for laboratory assessment					

III. Evaluation Question

13. In which of the following biology courses did you do more laboratory practical activities? (Rank them 1 to 14where 1 for most and 14 for least)

Code	Course name	Rank
A	Introduction to Biological Laboratory Techniques	
B	Phycology	
C	Bryophytes and Pteridophytes	
D	Seed Plants	
E	Invertebrate Zoology	
F	Vertebrate Zoology	
G	Cell Biology	
H	Mycology	

I	General Entomology	
J	Principles of Genetics	
K	Principles of Parasitology	
L	General Microbiology	
M	Plant Physiology	
N	Applied Entomology	

14. What was the minimum number of biology laboratory practical sessions in your three year of study?

1- 2 ☐
3 – 4 ☐
5- 6 ☐
7 -8 ☐
9- 10 ☐
11-12 ☐
13-14 ☐
15-16 ☐

15. What was the maximum number of biology laboratory practical sessions in your three year of study?

1- 2 ☐
3 – 4 ☐
5- 6 ☐
7 -8 ☐
9- 10 ☐
11-12 ☐
13-14 ☐
15-16 ☐

16. In which of the following biology laboratory practical activities did you get most important skill for your life career? ((Rank them 1 to 14 where 1 for most and 14 for least)

Code	Course name	Rank
A	Introduction to Biological Laboratory Techniques	
B	Phycology	
C	Bryophytes and Pteridophytes	
D	Seed Plants	
E	Invertebrate Zoology	
F	Vertebrate Zoology	
G	Cell Biology	
H	Mycology	
I	General Entomology	
J	Principles of Genetics	
K	Principles of Parasitology	
L	General Microbiology	
M	Plant Physiology	
N	Applied Entomology	

How do you evaluate the laboratory manual of the following biology courses?

Please indicate your answer by putting a tick mark (√) in the column of your best choice

	Course name	No manual	Not good	Good	V. Good	Excellent
17	Introduction to Biological Laboratory Techniques					
18	Phycology					
19	Bryophytes and Pteridophytes					
20	Seed Plants					
21	Invertebrate Zoology					
22	Vertebrate Zoology					

23	Cell Biology					
24	Mycology					
25	General Entomology					
26	Principles of Genetics					
27	Principles of Parasitology					
28	General Microbiology					
29	Plant Physiology					
30	Applied Entomology					

31. What is the contribution of the manuals to improve your understanding of the subject matter? (Rank 1 to 5 where 1 for most and 5 for least))

Code		Rank
A	To prepare before the laboratory	
B	To follow the procedures in order to performing experiments	
C	To write the laboratory reports	
D	To discuss concepts	
E	To design experimental techniques	

32. How many biology field trips you had in your three years of study?

None ☐

1 time ☐

2 times ☐

3 times ☐

4 times ☐

5 times or more ☐

***IV.* Biology Laboratory Skills:**

For each skill rate of your performance please indicate your answer by putting a tick mark (√) in the column of your best choice

	Skills	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
33	I am able to relate things learned in the class to daily life, transform them into practice and solve problems					
34	I am able to do experiments, and to use laboratory equipment					
35	I can design a scientific procedure to answer question					
36	I am able to conduct researches in various biological disciplines					
37	I am able to collect data systematically, catalogue and preserve field biological materials and museum specimens of plants, animals and microbes					
38	I am able to apply the techniques of culture media, and carry out culturing, isolation and identification of micro-organisms and report					
39	I am able to analyze and interpret biological data and write and present scientific reports					
40	I am able to operate basic biological equipment					
41	I am able to solve environmental and conservation problems of the Country.					
42	I can design ways to prevent infectious diseases					

Thank you for your cooperation, time and consideration

Appendix D: Questionnaire for Instructors

Dear Participant,

This study, "**An assessment of the state practical biology skills of undergraduate students in Ethiopian universities and the impact on their performance",** is a dissertation conducted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Life Science Education at Institute for Science and Technology Education, University of South Africa.

I am kindly requesting your participation. In order to keep your confidentiality as a participant of the survey, I would like to clarify that:

- Your response to the survey is totally voluntary.
- Results will be reported either in aggregate or without institutional or individual names (or other forms of identification)
- Responses to the survey will be kept confidential and secure, which means that the information will be coded and kept in a secure server and only the main researcher will be able to access such information.

I greatly appreciate your participation.

Sincerely,

Getachew Fetahi Gobaw

Ambo University

Email: getachewfetahi@yahoo.com

P.O.BOX: Ambo university post office 05

General Instruction: This questionnaire consists of two types of questions: closed ended questions and open ended questions. For closed ended question, choose the appropriate rate you feel and mark "√". For open ended question, write your responses in the blank space.

I. Demographic Data for Instructors

1. Level (year) you are teaching : ☐ ☐ ☐
   3rd
2. Gender : Male ☐ ☐
3. Qualification :

Diploma ☐
First Degree ☐
Second Degree (Msc) ☐
PhD ☐

4. Area of specialization ____
5. Year of teaching experience in higher education

1 -5 yrs ☐
6- 10 yrs ☐
11-15 yrs ☐
16- 20yrs ☐
21-25 yrs ☐
26-30 yrs ☐
31 and above ☐

6. Teaching load/week : Lecture __________Contact hrs. Laboratory _________hrs

II. Attitude questions

Please indicate your answer by putting a tick mark (√) in the column of your best choice

	Items	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
7	Number of students in each laboratory affects students' practical skill performance.					
8	Teaching in the laboratory is more interesting than teaching in class.					
9	The time allotted for each practical session is enough					
10	Laboratory manuals help student to understand better.					
11	The laboratory part of the courses should be taught only by assistant graduates					
12	Students should formulate hypothesis, design their experiment, conduct the experiment, collect data and report the results by themselves.					
13	Students should actively participate in the lesson and learn by observing and doing					

14	The biology laboratory practical activities are helpful to improve the concepts of the material covered in the classroom and to illustrate the theoretical part of the course					
15	The biology laboratory practical activities are very important for students future career to solve problems					
16	Project based laboratory work helps to stimulate student interest and participation					
17	The physical structures and facilities of the laboratory are appropriate for all biology laboratory experiments recommended in the harmonized curriculum to be implemented in the way it is intended					
18	The available laboratory recourses effectively and wisely used.					
19	Instructors should participate in in-continuous professional development training programs					
20	Teacher education should be improved					

III. Availability and Use of Laboratory Resources

21. How often do you use laboratory sessions?

Never ☐

Rarely ☐

Seldom ☐

Occasionally ☐

Always ☐

22. Do the courses you teach have laboratory sessions?

Yes ☐

No ☐

23. If your answer in question 22 above is "Yes" how many practical sessions are recommended in the harmonized curriculum? ______________________

24. How much of the recommended practical sessions are implemented in your lab?

1 -20% ☐

21 – 40% ☐

41 - 60% ☐

61 -80% ☐

81 – 100% ☐

25. What are the reasons not to implement others laboratory practical?

____

____

____

____

26. How do you rate the training you received in preparing to teach biological laboratory?

Poor ☐
Fair ☐
Good ☐
Very good ☐
Excellent ☐

IV. Laboratory Practical Skill Assessment Methods

27. How do you assess laboratory practical activities?

Written (Paper and pencil) exam ☐
Identification of specimen ☐
Individual practical test ☐
Only by laboratory reports and attendances ☐
Laboratory reports and Identification of specimen ☐
Laboratory report and written exam ☐

28. Why do you prefer this form of laboratoryassessment?

____

____

29. Do you have rubric (criteria) to evaluate laboratory reports?

Yes ☐
No ☐

30. If your response in question 29 above is "Yes", how often do you use rubric (criteria) to evaluate laboratory reports?

Never ☐
Rarely ☐
Seldom ☐
Occasionally ☐
Always ☐

What is your manipulative skill to conduct the following experiments?

	Manipulative skill	Poor	Fair	Good	V. good	Excellent
31	Efficient use Light microscope					
32	Spectrophotometer					
33	Electrophoresis					
34	Liquid chromatography techniques					
35	Qualitative Food test					
36	Microbial culturing, isolation and gram staining techniques					
37	Culturing and growing of fungi species					
38	Collection and preservation of insects					
39	Staining and identification of chromosomes during cell division					

40. Do you have well prepared laboratory manuals for the laboratory courses you teach?

Yes ☐

NO ☐

41. If your answer in question 40 above is “Yes”, how do you evaluate the laboratory manual/s you use ?

Poor ☐

Fair ☐

Good ☐

Very good ☐

Excellent ☐

42. What are the causes for the poor laboratory skill performance in the under graduate biology laboratory activities?

____

____

____

____

____

Thank you for your cooperation, time and consideration.

Appendix E: Semi-structured interview schedule for biology instructors and laboratory assistants

Place (University): ____

Date and time of interview: ______________________________

Introduction: Hello, my name is Getachew Fetahi Gobaw

The purpose of this interview is to information for my thesis entitled "assessment of the state practical biology skills of undergraduate students in Ethiopian universities and the impact on their performance" for a dissertation in partial fulfillment of the requirements for the degree of Doctor of philosophy in Life Science Education at Institute for Science and Technology Education, University of South Africa. The interviews will last for about half about 45 minutes and questions will deal with laboratory work experience in your university, particularly, biology laboratory.

All interview data will be handled so as to protect their confidentiality. Therefore, no names will be mentioned and the information will be coded. All data will be destroyed at the end of the project.

At any time, you can refuse to answer certain questions, discuss certain topics or even put an end to the interview without prejudice to yourself.

Interview questions:

1. Would you please introduce yourself?
2. How long did you serve at the university level?
3. Which course/s do you instruct?
4. What laboratory activities are being done in your course/s?
5. Does the course/s have laboratory guidelines/ manuals?
6. Who prepared the manuals?
7. What are the strengths and weaknesses of the laboratory manuals?
8. How do you judge the practices of the biology laboratory in your university?
9. What major challenges do you encounter while doing laboratory activities?
10. How do you evaluate the laboratory performance of your students?

11. How do you evaluate the performance of students in the biology laboratory?

12. Why do you use these techniques of evaluation?

13. How do you evaluate the availability of the laboratory equipment in your university?

14. What are the main reasons to have very few field trips?

Thank you for your time. Do you have any questions that you would like to ask me?

Appendix F: Ethical clearance

October 29, 2012

To : **Academic and Research Vice President**

Jima University [redacted]

Dear Sir

I am requesting permission to conduct the study entitled "**An Assessment of Undergraduate Biology Practical Activities in Ethiopian Universities",** a dissertation that will be conducted in partial fulfillment of the requirements for the degree of Doctor of philosophy in Life Science Education at Institute for Science and Technology Education, University of South Africa. I am biology instructor at Ambo University in the department of biology.

The purpose of this study is to evaluate the undergraduate biology laboratory practical activities in Ethiopian universities based on Kolb's experiential learning theory and five levels of Laboratory Task Analysis Instrument (LAI) in order to improve the learning process of biology laboratory practical activities. The study will be conducted in three universities, in the biology laboratories during November, 2012 to April, 2013 of third year students. The data collected will be used in my study, and will be confidential. Maintaining respondent's anonymity is a primary concern throughout the study. I believe there is no risk to the study participants. Participation is voluntary, and participants will retain the right to with draw from the study at any time, without penalty.

In each university, all undergraduate biology instructors and laboratory assistants and third year students will be required to participate in the study. The instructors and lab assistants will participate by completing questionnaires. Some of the teachers who answered the questionnaires will be interviewed. The students will be participated by completing questionnaires and performing individual practical laboratory tests. Observation on organization of the biology lab, laboratory manuals for each course (if any), and laboratory practical sessions will be conducted. UNISA Ethics Committee has carefully considered my research study and is satisfied that it conforms to the principles set out in the University's Code of Ethics for Research on Human Subjects.

Thank you for your anticipated cooperation in this regard.

Yours Faithfully,

Getachew Fetahi

UNISA university of south africa

Ref: 2013/ISTE/32

08 July, 2013

Mr. Getachew Fetahi Gobaw
(47243961)
Ethiopia

Dear Mr. Getachew Fetahi Gobaw,

REQUEST FOR ETHICAL CLEARANCE:

Title of Study: "The State of Practical Biology Skills of Undergraduate Students and Impact on their performance in Ethiopian Universities."

Your application for ethical clearance of the above study title as corrected was considered by the ISTE sub-committee in the College of Graduate Studies on behalf of the Unisa Research Ethics Review Committee on 4 July, 2013.

After careful consideration of the details and implications of the study, your application was **approved** and hence you can continue with the study at this stage.

Congratulations.

C E OCHONOGOR
CHAIR: ISTE SUB-COMMITTEE

CC. PROF L. LABUSCHAGNE
EXECUTIVE DIRECTOR: RESEARCH

PROF M N SLABBERT
CHAIR- UREC.

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