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Students' Perceived Environment, Attitudes, and Performance Skills in Chemistry Laboratory

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STUDENTS’ PERCEIVED ENVIRONMENT, ATTITUDES,

AND PERFORMANCE SKILLS IN CHEMISTRY LABORATORY

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In partial fulfillment

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with Specialization in Chemistry

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CERTIFICATE OF APPROVAL

The thesis attached hereto, titled **STUDENTS' PERCEIVED ENVIRONMENT, ATTITUDES, AND PERFORMANCE SKILLS IN CHEMISTRY LABORATORY**, prepared and submitted by AMOR CANSENO MALLARI in partial fulfillment of the requirements for the degree of **MASTER OF ARTS IN EDUCATION with specialization in Chemistry**, is hereby recommended for approval and acceptance.

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ABSTRACT

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This causal-correlation study assessed the impact of students' perceived laboratory environment and attitude towards chemistry laboratory on their laboratory performance skills. Collected data from the 109 Grade 10 students were subjected to statistical analysis using the Pearson *r* and regression analysis. Findings revealed that there were positive significant correlations between students' perception, attitude, and performance skills towards chemistry experiments. Using statistical data, the researcher found that the presence of a favorable laboratory environment and having positive attitude towards experiment can bring in more positive results to the performance of laboratory skills of the students. Furthermore, the results showed that students' attitude and perception towards chemistry laboratory could predict their performance skills during

experiments. The study contest chemistry teachers to foster students' interest as they perform experiments to ensure quality of work and skillsperformance. Rules in laboratory must always be clear to students to create a sense of predictability of doing what is supposed to be done in order to avoid consequences that may affect student's behavior and performance.

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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

Introduction

An international report on science education states that the emphasis of science education in basic education should be on engaging the learners in scientific processes and wonders. This emphasis can be best achieved through activities that involve extended investigative work, actual experiments, and other forms of inquiry-oriented science activities (Osborne & Dillon, 2008).

In the Philippines, due to the urgent and critical need in enhancing the quality of education, a development of a new curriculum was made—the K to 12 program (Cruz, 2015). This curriculum is designed around the three domains of learning science: learning to understand scientific knowledge in local and global settings and apply it in various contexts, performing scientific methods and skills, and establishing and demonstrating scientific attitudes and morals (K to 12 Primer, 2014).The attainment of these areasisaided using the following methods: multi/interdisciplinary approach, science-technology-society approach, contextual learning, problem/issue-based learning, and inquiry-based approach. Furthermore, thenewly implemented education program seeks to strengthen the quality of educationresultinginthe understanding of the learning competencies whiledeveloping a holistic learner. In this new program, the science education aims to increase scientific literacy in order for the students to make cautious judgments and decisions concerning the environment, health and the society (K to 12 Science Curriculum Guide, 2013). In her paper, Cabansag (2014) generalized the K to 12 science curriculum as a learner-centered and inquiry-basedcurriculumthat can only be achieved by utilizing classroom activities as concrete evidences when constructing explanations.

Science is not only concerned with the establishment of human knowledge coupled with problem-solving activities but also with the relation between theories and experiments (Reid & Shah, 2007). Laboratory work has been one of the features of science education in all levelsparticularly in chemistry. Science laboratories play a vital key in the learning environment where in students develops a better perception towards science, enhance their understanding in scientific concepts, and sharpentheirscience inquiry skills. It is a learning opportunity as students collaborate in small groups and work together in investigating a science phenomenon (Hofstein & Lunetta, 2004; Kurbanoglu & Akin, 2010).Historically, experiments were developed as learning strategy in order to confirm theories already taught in classroom (Reid & Shah, 2006). According to Morrell (as cited by Adane & Admas, 2011), laboratory work in chemistry education was originally developed in order to produce competent and skilled workers in different fields of industry and research laboratories. For a long period of time, there had been a lot of assertions about the importance of laboratory work in schools, but a handful of researches shows that it often acquires little meaningful learning by students (Hart, Mulhall, Berry, Loughran, & Gunstone 2000).

Hofstein and Lunetta (2004) laid down the factors that restrain students' learning in science laboratory, which includes the use of a "cook-book" style of laboratory guides that hampers the students in thinking about the larger purpose of their activity. Class size, inflexible schedules, inappropriate assessment tool that evaluates students' practical knowledge and abilities, andthelimitation of school's resources and access to technology tools are also worth mentioning.Teachersalso play an important role in their argumentation. Hofstein and Lunetta (2004)furthersuggest that teachers, as well as administrators, are often limited with knowledge and skills in handling laboratory work. This lack of understanding often leads to malpractices that likely influences students' perception and behavior in laboratory work.

For the past years, researches have been involved in the investigation ininteraction between students' cognitive and affective learning outcomes in science learning environment **(**Kardash & Wallace, 2001; Robles, 2003; Palada, 2002; Ferreira & Santoso, 2008; Avilla, 2009).The relationship of students' affective and cognitive learning during laboratory work had also been recognized in many literatures abroad(Quek, Wong, & Fraser, 2002; Russell & Weaver, 2008; Kingir & Aydemir, 2012; Saribas & Bayram, 2009; Kurbanoglu & Akin, 2010; Hofstein, 2004; Hart et al., 2000; Karisan & Yilmaz-Tuzun, 2013, Dogru, Gencosman, & Ataalkin, 2011).The amelioration of positive attitude towards chemistry is significant because attitudes foretell behaviors (Glasman & Albarracin, 2006). In the study of Kurbanoglu and Akin (2010), path analysis showed that the attitude of university students in chemistry laboratory served as mediator between their self-efficacy and anxiety. Students with positive attitude towards the activity tend to sustain more effort in their laboratory work and involvement in the learning tasks.This type of approach enhanced students' self-efficacy and believedthatfailure relies on their effort for the task (Saribas & Bayram, 2009).

In his paper, Hofstein (2004) suggested that educators should give focus on what their students are thinking in and about the science laboratory. It is very important that both the teacher and the students know the general and specific purposes of each experiment in the laboratory as this will serve as a guide in assessing if whether or not the purpose of laboratory work is obtained (Hofstein & Lunneta, 2004). Meester and Maskill observed (as cited by Reid & Shah, 2007) that,teachersgivetoo much emphasis on the experiment to be carried out and less focus on what the students should attain after the laboratory period. Studies have shown that students often perceive that the main purpose of their laboratory work is to simply follow a set of steps and to yield in getting the correct and expected results (Hofstein & Lunneta, 2003; Hart et al., 2000; Reid& Shah, 2007). Many students do not really know why they are doing laboratory work. Students, unlike educators, would always have a vague understanding of the essence of performing laboratory work unless they would have grasp of its theoretical value (Hart et al., 2007). Due to its complexity and lack of focused investigations, Hofstein and Lunneta (2003) suggested science educators to executeamore thorough and focused research that explore the interrelation of students' laboratory experiences and conditions in learning.These would help educators to acquire anextensive understanding to the construct of laboratory work.

The purpose of this study was to examine the unknown relationship between students' performance skills and their perceived environment and attitudesin chemistry laboratory toward their skills performance. It involved an analysis between the underlying affective domains in students' learning: perceptions and attitudes towardschemistry laboratory environment to their laboratory performance skills.

Conceptual Framework

Students' laboratory performance skills during chemistry laboratory may be affected by their perception about science laboratory environment and attitude towards chemistry laboratory. The following concepts and theories were used as basis for relating the different variable used as focus in this paper.

Laboratory Performance Skills

Understanding of science through laboratory exercises must not only be the sole focus of teachers and students during science experiments but also the assessment of students' laboratory performance skills (Hofstein & Lunetta, 2004). As defined by Calamlam (2013), laboratory performance skills are competencies that students must develop and master while performing specific parts of a chemistry experiment: before the experiment, during the experiment, after the experiment. These include procedural and physical preparations before the actual experiment, procedural execution and oral communication skills, leadership and collaboration, managerial and organizational skills, time and house keepings. Generally, instructors and teachers weigh students learning in chemistry laboratory through cognitive output but seldom give emphasis on students' performance skill—which is why science experiments were established in school set-up (Martin, 2000). In a study conducted by Strand, Naden and Slettebo (2009) to a group of bachelor students found out that learning in laboratories happens through training of performance skills and kinesthetic involvement. They further emphasized that mastery of skill is necessary prior to learning. In other words, active students' participation during laboratory experiments may contribute to their acquisition and understanding of scientific concepts intended for anexperiment.A series of investigation would be needed in order to assess students'performance outcomes during experiments that include their knowledge of what is scientific inquiry and skills, understanding related concepts and applications, and perceptions in laboratory work (Hofstein & Lunetta, 2004).

Affective Domains of Lab Laboratory Learning: Perception and Attitudes

The relationship between attitude and classroom achievement has been the subject of many studies conducted in the Philippines and abroad(Kardash & Wallace, 2001; Robles, 2003; Palada, 2002; Ferreira & Santoso, 2008; Avilla, 2009). The interrelation of cognitive and affective domains of student's learninghad been the focused of most educational studies particularly in science (Quek, Wong, & Fraser, 2002).

There has been a consistent positive result between the interactions of students' learning environment and their learning outcomes— both cognitive and affective (Fraser and Griffiths, 1992). Efforts, in terms of evaluation tool, in assessing students' perception in their learning environment had been the focused of several researches abroad (Kalu, 2004; Russel & Weaver). One of which is the Science Laboratory Environment Inventory (SLEI) by Fraser, Giddings and McRobbie (1993). The assessment tool has 35-structured item questionnaire composed of rating scales on how often the students would see a certain practice, situation, or laboratory condition during science experiment. The practices involved in the questionnaire were divided into five domains: Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment.*Student Cohesiveness* measures how students' support one another;*Open-Endedness* measures the flexibility of the experimentation to which students can use other methods of experimentation aside from what was suggested by the teacher or instructor; *Integration* measures the extent of laboratory experiments to either confirm or demonstrate a scientific idea learned in the classroom; *Rule Clarity* measures students' awareness to the implemented rules that guides their behavior during laboratory experiments; and *Material Environment* measures the adequateness of laboratory materials and equipment during experiments (Fraser& Griffiths, 1992).

Similarly, the development of positive attitude towards chemistry is significant because attitude foretells behavior (Glasman & Albarracin, 2006).A review of science laboratory-related literatures by Hofstein and Lunetta (2004) found that students enjoy doing laboratory work that led to improvement of their laboratory performance but limited number of these literatures precisely discussed how affective domains such as attitude and interest may affect such positive result. Evaluation tools, such as the Attitude Towards Chemistry Laboratory Work (ATCLW) developed and validated by Hofstein, Ben-Zvi and Samuel (1976), was used to develop an understanding on students' attitude that could be beneficial to the teacher's interest by learning more about laboratory experiments. The tool is composed of five domains of students' attitude towards laboratory experiments namely: Interest, Enjoyment, Practicality, Way of Learning, and Valuable, which are assessed using a 5-point Likert scale. *Interest* assesses student's interest in doing chemistry experiments; *Enjoyment* entails student's enjoyment in performing experiments and handling apparatus; *Practicality* assess the extent of practicality in doing experiments; *Way of Learning* measures how students' consider laboratory experiments as part of the learning process;

and *Valuable* measures how students give importance to science experiments (Abdullah, Mohamed, & Ismail, 2008).

For decades, educators and researchers have proven the positive impact of having positive attitude and perception towards a subject to student's achievement in school (Hofstein & Lunetta, 2004).Positive attitude also promotes development in skills such as cooperation and communication (Hofstein, 2004). In the local setting, Robles (2003) concluded in her study how students' attitude towards Chemistry—in general— affects their achievement in the subject. Her study shows that students who display positive attitude towardsthe subject tend to study the subject efficiently and get higher achievement than those who perceive the subject as difficult. Similarly, a study for the correlation between students' perception and achievement undertaken by Palada (2002) suggested a positive link between the two variables. Students who perceivedchemistryas a subject full of fun and exciting activities showed higher achievement in the subject than those who do not. Chemistry is an experimental science. The positive results could be associated on the nature of the subject. Tobin (as cited by Hofstein & Naaman, 2007) suggested that meaningful learning in science is possible if students are given the chance to construct their knowledge through handling of materials and equipment.

Using the concepts and theories presented above, this study focused in determining the how students' science environment perception and attitude towards laboratory work may affect their performance skills during chemistry experiments as shown in Figure 1.

Research Paradigm

The figure below shows the relationship of the variables used in this study:

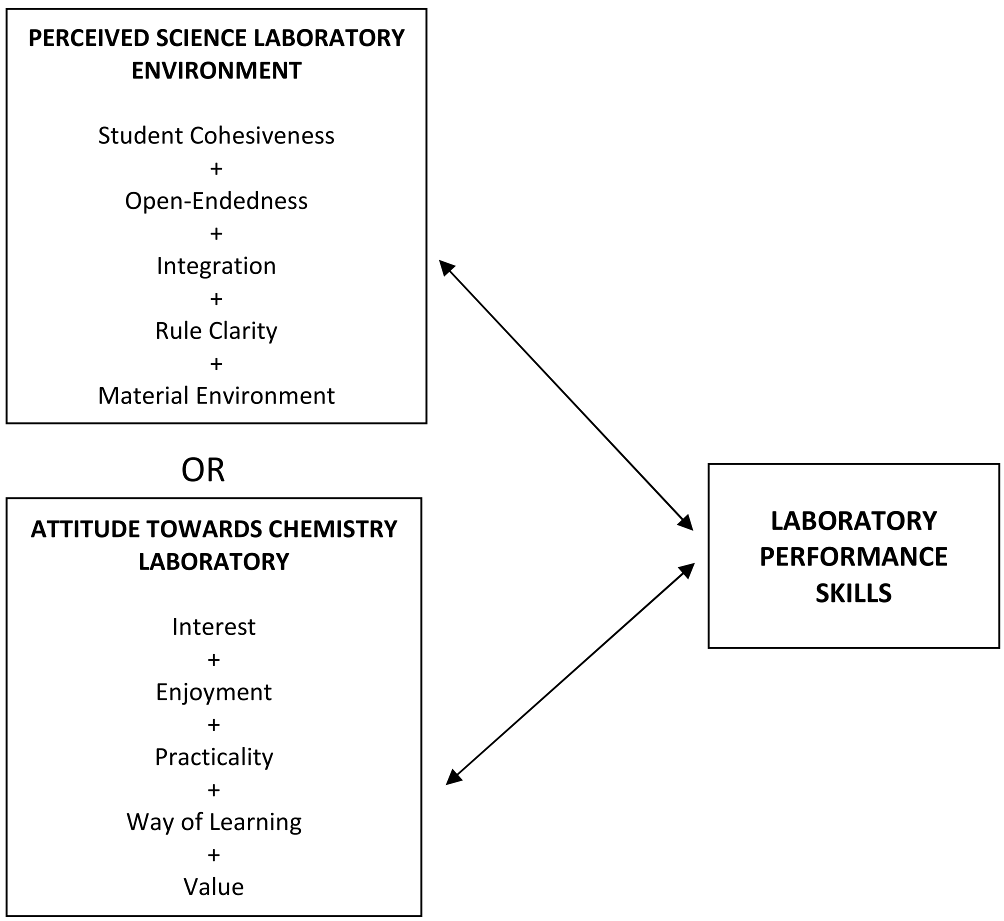

*Figure 1.*Research Paradigm

The study focused on the possible interactions between students' laboratory performance skills in chemistry laboratory to either their attitudes or their perceptions to laboratory experiments. The paradigm illustrates how students' science laboratory environment perceptions— in terms of student cohesiveness, open-endedness, integration, rule clarity, and material environment— or attitude—in terms of interest, enjoyment, practicality, way of learning, and valuing— may affect their performance skills during the conduct of laboratory experiments in chemistry.

Students from three intact classes were given checklists to determine their perceived science environment and attitudes towards chemistry laboratory experiments. A validated instrument was used during laboratory experiments to assess students' laboratory performance skills while conducting an experiment.

Statement of the Problem

The study focused in determining the relationship between students' science laboratory perceptionand attitude toward their performance skillsin chemistry laboratory. Specifically, it sought to answer the following questions:

1. What are the students' profile in chemistry laboratory in terms of:

    1.1 attitudes towards chemistry laboratory,

    1.2 perceived science laboratory environment, and

    1.3 laboratory performance skills?

2. Are there significant differences in laboratory performance skills of the students when they are categorized according to:
   2.1. attitudes towards chemistry laboratory, and
   2.2. perceivedscience laboratory environment?
3. Is there a significant correlation between:
   3.1. students' attitudes towards chemistry laboratory and laboratory performance skills, and
   3.2. perceivedscience laboratory environment and laboratory performance skills?
4. Do attitudes towards chemistry laboratory and perceived science laboratory contribute on students' laboratory performance skills?

Hypothesis

The following hypotheses were set for specific problems 2, 3, and 4:

1. The students' laboratory performance skills have no significant differences when they are categorized according tostudents'attitudetowards chemistry laboratoryandperceivedsciencelaboratory environment.
2. The students' laboratory performance skills have no significant correlation to students' attitude towards chemistry laboratoryandperceivedscience laboratory environment.

3. The attitudes towards chemistry laboratory and perceived science laboratory contribute to students' laboratory performance skills in chemistry.

Significance of the Study

The study aims to contribute in our understanding of laboratory experimentation and improvement in using experiments in the classroom set-up. The study may be valuable to the following individuals:

Science teachers – science teachers always seek for ways to enhance the overall learning of their students. This research may provide science teachers an over view of students' attitudes and perceptions towards chemistry experiments. The study may be beneficial in their preparation before conducting an experiment especially the materials, venues, and manuals.

High school administrators – this study may also be useful to school administrators to restructure their school's curriculum offering especially for the subject that has experiments as one component of student's learning outcome. High school administrators can likewise use this research in evaluating the syllabus that will suit to what students expects from a laboratory environment.

Researchers—future researchers that will focus on laboratory instructions may find this research helpful in gaining an understanding in the interrelation of students' laboratory performance skills, attitudes, and perceptions in chemistry laboratory.

Scope and Delimitation of the Study

The study focused in determining relationship between students' perception and attitude in chemistry laboratory work towards their skills' performance.

The study was conducted atSt. Scholastica's Academy Marikina, an exclusive all-girls catholic school. All the Grade 10 students in the three intact sectionswhoweretaking chemistry classesparticipated in the study, school year 2015-2016.The data for this study was collected usingquestionnairesthat aimed to identify students' preferred science laboratory environment and attitudes on chemistry laboratory. To determine the students' attitude towards chemistry laboratory—in terms of Interest, Enjoyment, Practicality, Way of Learning, and Value—theAttitude Towards Chemistry Laboratory Work developed by Hofstein et al. (1976) was. On the other hand, Science laboratory Environment Inventory—a survey tool based from the work of Fraser et al. (1993)—helped gathered students' perceptions about laboratory work in terms of Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment.

A Laboratory Performance Observation Assessment Tool developed by Calamlam (2013)was used by the teachers to evaluate the performance skills of the students during laboratory experiments. The rubric had the following components: procedural and physical preparedness for the experiment, execution of laboratory techniques and skills mastery, collaboration and leadership, task management, safety, professionalism, results and analysis, time management, and cleanliness.

Definition of Terms

The following terminologies were used in the study that focused in determining relationship between students' perception and attitude in chemistry laboratory work toward their skills performance.

Attitude – the positive or negative tendency of an individual to any matter (Dogru, Gencosman, &Ataalkin, 2011).The term was operationally used as the behavioral reactions of students towards laboratory work in terms of interest, enjoyment, practicality, way of learning, and value that was measured using the Attitude Towards Chemistry Laboratory tool.

Enjoyment – a component of the Attitude Towards Chemistry Laboratory Work tool that evaluates how the students find enjoyment in doing an experiment (Abdullah, Mohammed, & Isamail, 2008). The term was operationally used to identify if students enjoy performing a chemistry experiments.

Integration - a component of Science Laboratory Environment Inventorythat evaluates the degree of the experiment in terms of integrating non-laboratory and theory classes (Fraser & Griffiths, 1992). The term was operationally used as an indicator that assesses whether scientific theory is incorporated during laboratory experiments.

Interest – a component of the Attitude Towards Chemistry Laboratory Work tool that evaluates how the students find interest in doing an experiment (Abdullah et al., 2008). The term was operationally used to identify if students find chemistry experiments as an interesting way of learning the subject.

Laboratory performance skills – these are competencies that students must develop and exhibit while performing specific parts of chemistry experiments: before the experiment, during the experiment, after the experiment (Calamlam, 2013). It includes procedural and physical preparedness for the experiment, execution of laboratory techniques and skills mastery, collaboration and leadership, task management, safety, professionalism, results and analysis, time management, and cleanliness.

Material environment - Fraser and Griffiths (1992) defines material environment as a component of Science Laboratory Environment Inventory that evaluates the adequateness of equipment and materials in the laboratory. The term was operationally used as an indicator that assesses the extent of availability of the materials in the laboratory to accommodate all the students.

Open-endedness – Fraser and Griffiths (1992) defines open-endedness as a component of Science Laboratory Environment Inventory that evaluates the nature of the activity where students can freely use a method of experimentation they prefer to attain the objectives of the experiment. The term was operationally used as an indicator that emphasizes an open-ended, non-traditional, non-stereotype, divergent approach to science experiments.

Perceived laboratory environment– this is composed of students' indicators of what a student-friendly science laboratory is that includes student cohesiveness, open-endedness, integration, rule clarity, and material environment that can be measured using the Science Laboratory Environment Inventory.

Practicality – a component of the Attitude Towards Chemistry Laboratory Work tool that evaluates how the students find experiments as more practical way—consuming less time—of learning chemistry than any other forms of teaching instruction

(Abdullah et al., 2008). The term was operationally used to identify students' choice between doing laboratory experiment and watching laboratory instructions.

Rule clarity - a component of Science Laboratory Environment Inventory that evaluates the degree of student's behavior during laboratory activity is directed by prescribed rules (Fraser & Griffiths, 1992). The term was operationally used as an indicator ofstudent's agreement in performing chemistry experiments where directions and procedures to be carried out are clear and well defined.

Student cohesiveness – a component of Science Laboratory Environment Inventory that evaluates the degree of students' familiarity to one another, help and support each other (Fraser & Griffiths, 1992). The term was operationally used as an indicator that determines how the students learn together as a group and ensures oneness while conducting an experiment.

Value – a component of the Attitude Towards Chemistry Laboratory Work tool that evaluates the values of doing chemistry experiments in the life the students (Abdullah et al., 2008). The term was operationally used to identify if students find relevance in performing chemistry experiments in terms of life applications and problem solving.

Way of learning – a component of the Attitude Towards Chemistry Laboratory Work tool that evaluates how the students find experiments as more effectiveand better way of learning chemistry topics than any other forms of teaching instruction (Abdullah et al., 2008). The term was operationally used to identify if students consider experiments as a valuable part of learning chemistry.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter presents the trends in science education and how laboratory experiments play a vital role in learning the subject. It also includes the factors that may affect—improve or hinder—the learning process when students perform laboratory experiments.

A. Science and Laboratory Experiments

The significance of laboratory experiments in science had long been the focus of several studies in science education. It has also been a major feature of science course particularly in chemistry (Reid & Shah, 2007). Laboratory experiment was described in their study as a practical activity performed by students wherein they were given an opportunity to work, manipulate, and use chemicals and equipment in chemistry laboratory.Though the purpose of experiments were to make observations to probe a proposed explanation or to generate new thoughts (Millwood & Sandoval, 2004), experiments conducted in school set-up were primarily only usedin order confirm an existing theory or idea learned in classroom (Reid & Shah, 2007). As proposed by Carnduff and Reid (2003), the essence of using laboratory experiments in chemistry education could be categorized into three broad areas:

1. *Practical skills*. This entails the development of skills in risk, health and safety handling, following procedures, proper use equipment, handling chemicals, and getting the necessary observations.
2. *Transferrable skills.* This includes time management, team work and collaboration, oral communication skills, data interpretation and presentation, strategizing and organizing, and problem-solving.
3. *Intellectual stimulation*. This takes into account on how students make necessary connection of laboratory experiments to real-world applications. It also includes the goal of uplifting student's enthusiasm in studying the subject.

In a more specific reason of including experiments in chemistry curriculum, Carnduff and Reid (2003) suggested the following intentions as to when experiments will be valuable in teaching the subject:

1. To illustrate key ideas and concepts
2. To have a concrete visualization of things learned in classroom
3. To introduce an apparatus or equipment
4. To develop a laboratory skill and safety
5. To teach how to make experimental design
6. To develop observational skills
7. To develop data gathering and interpretation skills

8. To improve group collaboration and team work

9. To show how a theory was develop from experimentation and observation

10. To develop data analysis, reporting, and discussion

11. To improve time management and flexibility skills

12. To build confidence and self-motivation

13. To develop problem solving skills

Laboratory experiments are also good sources of information for students. Figure 2 shows the various sources of information a student can acquire during laboratory experiments.

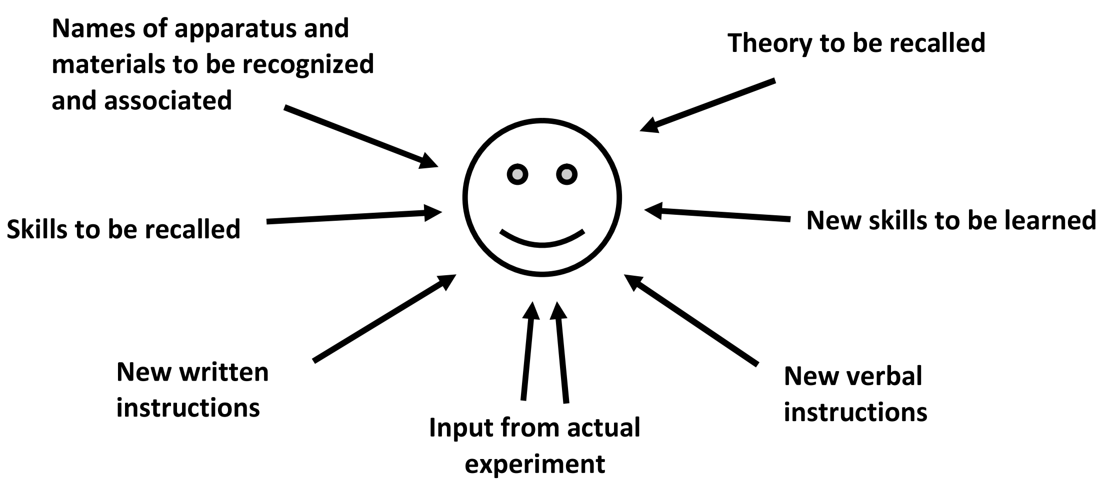

*Figure 2.*Sources of information for students in undergraduate laboratories (derived from Johnstone &Wham, 1982)

The figure shows that acquisition of information is done throughout the experimentation. At the start of each experiment, students are already required to recall skills and theories in order to have a jumpstart in performing the task. This can be followed by acquisition of knowledge in naming apparatus and how it is used, learning new skills, and the development of new written and verbal instructions. Finally, the concluding information is the over-all input of the actual experiment that is based on the purpose of the experiment.

In science laboratories, series of steps in conducting experiments are necessary to minimize the information load for the students (Reid & Shah, 2007). First, a pre-laboratory activity is done in order to prepare the students for the learning activity at hand. This involves the overview of the experiment, the objectives of the activity, materials and equipment orientation, and safety hazards. Next, the actual experimentation is conducted wherein most of the new information and skills are developed. Finally, a post laboratory is conducted not identify the expected results but to evaluate the process of experimentation and integrate new learning in the 'real world'.

Various styles of laboratory experiment approach can be found in science education. Table 1 presents Domin's (1999) four descriptors of laboratory styles that educators can use to determine what appropriate form of experimentation is suitable for their target objectives.

Table 1

Descriptors of the Laboratory Instructional Styles (adapted from Domin, 1999)

Style	Descriptor		
	Outcome	Approach	Procedure
Expository	Predetermined	Deductive	Given
Inquiry	Undetermined	Inductive	Student generated
Discovery	Predetermined	Inductive	Given
Problem-based	Predetermined	Deductive	Student generated

The table presents the laboratory styles that can be used in different situations during the planning of laboratory experiments, which are based on the expected outcome of the students, the approach of students, and how the procedures or instructions be conducted. Though several styles are available, still, the most common style used in almost all laboratory class is the expository or ‘cook-book’ laboratory style (Domin, 1999). Several studies regarding the comparative analysis of these styles had been the focus of Domin (2007) in his study. He found out that even if several contrary for these styles have been established, yet none was able to establish the most effective style over the other.

In order for the laboratory work to be effective, students and teachers must havea clear understanding on the goals, objectives, and purpose of the activity (Reid & Shah, 2007).An ambiguity on students' perception on the purpose of the experiment could lead to students’ negative attitude towards the activity. In the study of Milwood and Sandoval (2004) about students’ perception on the purpose of the experiment, it was found that there was a misalignment between their laboratory perception and the purpose of why scientists conduct experiments. Students perceived that laboratory experiments in school are done in order to work with materials that would ultimately lead in attaining the ‘right’ answer while scientist conduct experiments in order to gain understanding on a phenomena. Students do not have a clear boundary between understanding a phenomenonand producing the phenomenon (Carey & Evans, 1989). After the analysis of several literatures about the effectiveness of laboratory work in science education, Hofstein and Naaman (2007)found that, in general, none was able to show relationship between student’s achievement in laboratory and their laboratory experiences.

B. The Science Laboratory as a Learning Environment

Classroom learning environments in science have been studied extensively for couple of years in order to determine its relationship to teaching strategies and the social interactions between teacher-students, students-students, and students-subject matter, during the process of instruction (Martin, 2000). An analysis of available literature found that the learning environment could affect instructional method (Hofstein & Lazarowitz, 2001). This learning had been used in several schools in order to improve instructional pedagogy in science curriculum. Furthermore, it was suggested that information about students’ perceptions on their classroom learning environment could guide curriculum developers, teachers and administrators for their professional development, in searching for improved instructional techniques and teaching-learning methods that can contribute to positive aspects of the classroom environment (Palada, 2002).

Science educators—teachers and curriculum makers—are always challenged in formulating curricular materials, strategies, and pedagogy in instruction that are designed based on learners abilities, capacities, and aptitude (Martin, 2000). This entails that educators must allow a learning environment where collaboration among students prevails during the academic hour. Hands-on exercises, inquiry-based activities, and self-directed strategies could help in the attainment of this principle.The science laboratory could be an essential tool in the attempt in constructing a learning environment where students are directed in constructing their knowledge basedin their understanding of scientific concepts as well as skills related to the scientific process(Martin, 2000).

Laboratory experiments is a unique learning environment where students deals with materials and equipment they manipulatively use in order to observe the principles and goals observed in the environment (Hofstein & Naaman, 2007). There are times that students will work individually but most of the time, students collaboratively perform an experiment with other students in attaining its objectives. Some experiments are designed to be performed either inside or outside the laboratory; teacher's supervision can be in the form of minimal supervision or teacher-directed—where procedures were all pre-determined and the materials were already prepared. The latter form of laboratory environment is common in science laboratories where 'cook-book' style of experimentation is observed. This form of experimentation provides students with definite knowledge to specific goals of the laboratory experiment that gives little to no chance to students to form alternate answers/solutions. This contributes to students' perception that there could only be one solution and one answer to every question (Millwood & Sandoval, 2004).

The purpose of laboratory experiment is very simple, to create a learning environment that: first, would allow students to actively participate in acquisition and formation of scientific knowledge; second, to actually see how scientific theories and principles were formed and justified; and third, to understand how the implication and importance of scientific theories and principles were obtained (McDermott, Shaffer, & Constantinou, 2000). According to Duhem (as cited by Koponen & Mantyla, 2006), laboratory environments must provide a venue for students' actualization that experimentations are performed as a continuation of learning the theories. As part of the learning process, science laboratories must therefore be strategized in order to cater the following key objectives (Akinbobola, 2011).

- Arouse students' interest in using their science process skills;
- Mastery of the subject;
- Involvement of students in an inductive teaching approach than traditional approach;

- Students’ preferences in performing experiments than any form of teaching strategy;
- Advancement in the nature of science;
- Cater all types of learners including advance, slow, average, and gifted students;
- Development of competency in executing science process skills;
- Allow students to decide and strategize their method of learning;
- Stimulate students’ interest in learning science;
- Enrich teamwork and leadership abilities; and
- Realize the complexity and obscurity in dealing with practical work.

A number of literatures were found that dwell on the position of laboratory experiments in science education that led to a pool of theories that could help improve this type of learning strategy (Russell & Weaver, 2008). Without having any form of laboratory experiment during chemistry classes, students are left having a perception that chemistry is an abstract and theoretical subject (Reid & Shah, 2007). However, these studies failed into account on how students perceived the purpose and objective of an experiment and whether or not experiments are venues for learning in school (Millwood & Sandoval, 2004).According to Adane and Admas (2011), a learning-strategy would only be effective if students have a clear understanding of its purpose in the learning process. However, most of the objectives of experiments used in school laboratories were already prepared and designed by teachers or experts without having any form participation from the students. There was also an identified disconnection between student and professor perceptions on the purpose of the laboratory experiments (Palada, 2002). It was found that students' initial perceptions of laboratory experimental aims are significantly different from the aimsofthe teacher.This disconnection had been the subject of several studies but all failed into account the purpose of the laboratory experiment as a whole. Reid and Shah (2007) studied how the perception of undergraduate students affected their reaction to laboratory work and found out that students who have unclear knowledge in the purpose of experimentation in school tend to have negative reactions towards it; they perform experiments without having proper motivation and end goal. However, prolonged student exposure to consistent experimental goals in the classroom can lead to better student-professor alignment (Russell & Weaver, 2008).

C. Student's Attitude and Perception: Influence to School's Performance

Educators acknowledge that there are a multitude of reasons why students do not achieve academically in the classroom. As this study was designed to determine a possible link between students' attitudes and perceptions and their academic achievement, this part of literature review includes only studies that focus on students' attitudes and perceptions.

Lilian Bandong (2003) examined the self-perceptions of students in gifted programs and general education students in relation to their final grade. The author suggested that academic self-concept helps to predict academic achievement and goes on to explain findings that suggest for both gifted students and the general population of high school students, final grade and academic self-perceptions were moderately and positively related and that the structure of the relationship between academic self-perceptions and final grade was similar.

In a study conducted by Bernardo, Limjap, Prudente and Roleda (2008), students in elementary and high schools in different provinces showed five dimensions to their science perceptions that were affected by their teachers teaching pedagogy and science learning environment:

1. *Learner-centered pedagogy.* Teachers' practice of using classroom strategies that assists students learning.
2. *Science inquiry activities.* Science classes promote inquiry approach through activities that facilitates active learning of the students.
3. *Positive effects and beliefs*. Learning environment affects student's motivation and achievement in science classes.
4. *Grades as feedbacks*.Academic grades reflect student's learning ability in science that can be used to determine their preferred learning strategies.
5. *Support for self-learning and effort*. Learning strategies used by students can result in different consequences and support their performance in the subject.

On the other hand, attitude towards science cannot be simply be defined because attitude in science is a product of several components (Hofstein & Mamlok-Naaman, 2011). Some of these are anxiety, beliefs, curiosity, opinions, and other affective variables. A summary of these components commonly used in studies were summarized by Osborne, Simon, and Collins (2003):

- science teachers' perception
- students' anxiety towards science
- significance of science
- students' self-esteem towards science
- students' enthusiasm in learning science
- peer-attitude towards science
- students' enjoyment in learning science
- science classrooms' learning environment
- science achievements and failure in science courses
- preference in the pedagogy of learning science
- admission in science courses

In a related study, Liu, Maddux, and Johnson (2004) indicated that studies have suggested that students' attitudes are related to their success in learning, and concluded that positive attitudes might transfer to increased achievement. The authors reported that four attitude-variables (enjoyment, motivation, importance, and freedom of anxiety) have linear relationships with achievement. They summarized their study by saying that at least from one perspective, positive attitudes are transferred into higher achievement. Using the Science Learning Environment Inventory (SLEI), Hofstein, Nahum and Shore (2001) found that there was a significant difference between student's preferred chemistry laboratory environment and what is the actually occurring in their class. Furthermore, their results also showed that no matter what style of experimentation—inquiry-based and expository—wereused; student's perception to chemistry laboratory would still be the same. Open-endedness (directions in experiments are not readily given by the teacher), together with Integration (incorporation of theories learned in classroom), showed the most preferable expectations in chemistry laboratory by the students (Hofstein et al., 2001).

In summary, the literatures support the notion that students' positive attitudes, thoughts, and perceptions can translate into academic success in the classroom or, at the very minimum, can help to predict success and achievement in students.

CHAPTER III

METHODOLOGY

This chapter presents the methods of procedures to be used for the research. More specifically, it discusses the variables and measures to be used, sources of data, instruments to be used, procedures in the conduct of research and treatment of research data. This portion of research report likewise presents the research data and corresponding analysis and interpretation made by the researcher.

Research Design

The study attempted in determining the causality of students' laboratory performance skills in chemistry. Two variables—attitude towards chemistry laboratory and perceived science laboratory environment—were tested to determine whether or not they may be linked in the way students executed their performance skills during laboratory experiments. Hence, the study used a casual-comparative research method since the study investigated the causes that gave rise to an existing behavior—laboratory performance skills—without having a direct control over the independent variables—attitude towards chemistry laboratory and perceived science laboratory environment.

Participants of the Study

The respondents included in this study werethe 109 Grade 10 all-femalehigh school students at St. Scholastica's Academy Marikina (SSAM) during the first quarter of school year 2015-2016. Based on the Association of Benedictine Schools' Achievement Test, in general, the students can be described having an above intellectual ability in science. The test also showed that the students are proficient in reading and language comprehension, and excellent in number analysis. For Grade 10 classes, chemistry was held during the first quarter of the year. Three sections handled by the researcher were used as respondents in the research. The total number and list of students of the class were obtained from the office of the registrar of St. Scholastica's Academy Marikina.

Three experts were invited to participate in the evaluation of the five experiment sheets used in the study. The information about the experts can be found in Appendix A. Similarly, the researcher also invited two chemistry teachers, both teaching at St. Scholastica's Academy Marikina, to evaluate the students' laboratory performance skills during the execution of the five experiments.

Research Locale

This study was conducted at St. Scholastica's Academy Marikina (SSAM)—an exclusive all-girls Catholic school located in Marikina that gives academic offering from kinder to high school. It was established in accordance with the policies and standards set by the Department of Education and owned and administered by the Missionary Benedictine Sisters of Tutzing. It was registered with SEC as a non-stock, non-profit corporation, with its assets and income used directly and exclusively for educational purposes including expansion when needed to carry out the aims and objectives of the school. There were seven (7) sections for each year level in high school with an approximation of 42-45 students within a heterogeneous class. The school considers laboratory experiments as essential part of the students' learning in science.

Research Instruments

The following instruments were used to gather data and information about the students' perceived laboratory environment, attitudes towards chemistry experiments, and laboratory performance skills.

Science Laboratory Environment Inventory(SLEI) -- Thestudents' perceived laboratory environment was determined using the SLEI adapted from Fraser et al. (1993), which was a 35-structured item questionnaire composedof laboratory practices that students would want to see during a laboratory experiment(See AppendixC). The scale ranged from always (1) to almost never (5) in terms of the students' likeness to observe the given situation while performing their experiment in chemistry laboratory. The students' perceived laboratory environment involved in the questionnaire was classified according to Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. *Student Cohesiveness* measures how students' support one another; *Open-Endedness* measures the flexibility of the experimentation to which students can use other methods of experimentation aside from what was suggested by the teacher or instructor; *Integration* measures the extent of laboratory experiments to either confirm or demonstrate a scientific idea learned in the classroom ; *Rule Clarity* measures students' awareness to the implemented rules that guides their behavior during laboratory experiments; and *Material Environment* measures the adequateness of laboratory materials and equipment during experiments (Fraser& Griffiths, 1992). All dimensions have equal number of items that were equally distributed in the entire questionnaire. Reverse coding was used for negative items to compare the mean factor values.

Researches have already confirmed its reliability and validity even when used in different cultural setting and 21st century science process skill—data collection, organization and interpretation of data, measuring, observation, prediction, thinking, and reasoning (Quek, Wong, & Fraser,2002; Lightburn & Fraser, 2002). The analysis of results was done using the statistical limit analysis developed by the researcher with the aid from the experts. The limits were 1.00-1.49, 1.50-2.49, 2.50-3.49, 3.50-4.49, and 4.50-5.00 with the corresponding equivalence: the person strongly agrees to the idea, the person agrees with the idea, the person cannot compromise whether she agrees or disagrees to the idea, the person disagrees with the idea, and the person strongly disagrees to the idea, respectively.

Attitude Towards Chemistry Laboratory Work (ATCLW)--The questionnairedeveloped and validated by Hofstein et al. (1976) was used. The survey was a 25-structured item questionnaire composed of 5-point Likert scale. The scale ranged from stronglydisagree(1) to strongly agree (5) in terms of the students' agreement to the given description about the chemistry laboratory(See AppendixD).The statements were a combination of positive and negative statements classified into: Interest, Enjoyment, Practicality, Way of Learning, and Valuable. *Interest* assesses student's interest in doing chemistry experiments; *Enjoyment* entails student's enjoyment in performing experiments and handling apparatus; *Practicality* assess the extent of practicality in doing experiments; *Way of Learning* measures how students' consider laboratory experiments as part of the learning process; and *Valuable* measures how students' give importance to science experiments (Abdullah et al., 2008).Reverse coding was used for negative items to compare the mean factor values. The analysis of results was done using the statistical limit analysis developed by the researcher with the aid of experts. The limits were 1.00-1.49, 1.50-2.49, 2.50-3.49, 3.50-4.49, and 4.50-5.00 with the corresponding equivalence:the person strongly disagrees to the idea,the person disagrees with the idea,the person cannot compromise whether she agrees or disagrees to the idea,the person agrees with the idea, and the person strongly agrees to the idea, respectively.

Laboratory Performance Skills Assessment Tool (LPOAT)-- A validated and reliable assessment tool developed by Calamlam (2013) in order to evaluate the laboratory performance skills of the students during laboratory experiments was used in this study. The rubric has the following components: inclusion of*procedural and physical preparedness for the experiment, execution of laboratory techniques and skills mastery, collaboration and leadership, task management, safety, professionalism, results and analysis, time management, and cleanliness*(See Appendix E). The interpretation of mean scores was done using the following mean limits: 3.50 - 4.00 described that performance skill was always observed; 2.50 – 3.49 described that the performance skills was often observed; 1.50 – 2.49 described that performance skill was sometimes observed; and 1.00 – 1.49 described that performance skill was never observed.

Chemistry Laboratory Experiment-- This research utilizedfive (5) laboratory experiments within the target quarter of administering the study: Identifying Gases, Identifying Organic Compounds, Law of Conservation of Mass, Reactions of Metals with Hydrochloric Acid, and Types of Chemical reactions(See AppendixF).

Validation of the Experiment Sheets

The created experiment sheets—Conservation of Mass, Identifying Gases, Identifying Selected Biomolecules, Reaction of Metals with Hydrochloric Acid, and Types of Chemical Reactions—experiencedacceptance through the utilization of conclusions, remarks and recommendations received from three experts by using an instrument for validation (See Appendix G). The validity of the instruments was determined by collating the recommendations and suggestions of the experts on the instruments' content, lay-out, and language.

After the analysis of the experts' feedbacks, experiment sheets were found to be valid in terms of their content, lay-out, and language validity after gathering more than 50% of positive remarks from the experts. Minor revisions were still included based from the experts' advice in terms of simplicity of words and verb construct.

Data Gathering Procedure

A letter of permission to conduct research was given to the school directress. Likewise, the researcher soughtapproval fromthe parents or guardians of the students regarding the participation of their daughters in this research. Three intact classes were used in the study composed of 43 students per section. Out of 129 students, 109 students were allowed to be part of the study. Three experts examined and validated the five experiment sheets used in the study—IdentifyingSelected Biomolecules, Law of

Conservation of Mass, Reactions of Metals with Hydrochloric Acid, Types of Chemical Reaction, and Identifying Properties of Gases—were used in the course of the study.The students attended an orientation before conducting the initial survey. An initial administration of the Science Laboratory Environment Inventory (SLEI) and Attitude Towards Chemistry Laboratory Work (ATCLW)was done to gather students' perceptions towards laboratory environment—in terms of student cohesiveness, open-endedness, integration, rule clarity, and material environment—and attitude towards chemistry laboratory—in terms of interest, enjoyment, practicality, way of learning, and value.The research followed a time series design wherein the sample groupwas repeatedly evaluated after each experimentswasconducted. In this way, immediate feedbacks about students' affective (perception and attitude) and psychomotor (laboratory performance skill)have been observed. The Laboratory Performance AssessmentToolwas used by the evaluators—researcher and two chemistry teachers—toassess the skills of the students as they conduct the experiment during their laboratory period.

Statistical Tests

The profile of the students in terms of their perceived laboratory environment, attitude towards chemistry laboratory, and laboratory performance skills were identified using frequency distribution, mean difference, and ranking of students' response from the tools used. The significant differences of students' laboratory performance skills by perceived laboratory environemnt and significant differences of laboratory performance skills by attitude towards chemistry laboratory work were interpreted using One Way ANOVA. The Pearson r and standard regression coefficient (β) was used to identify the strength of significant relationship between students' perceived laboratory environment, attitude towards chemistry laboratory work, and laboratory performance skills.

The summary of the research procedures utilized in the study is presented using a chart in Figure 3 below.

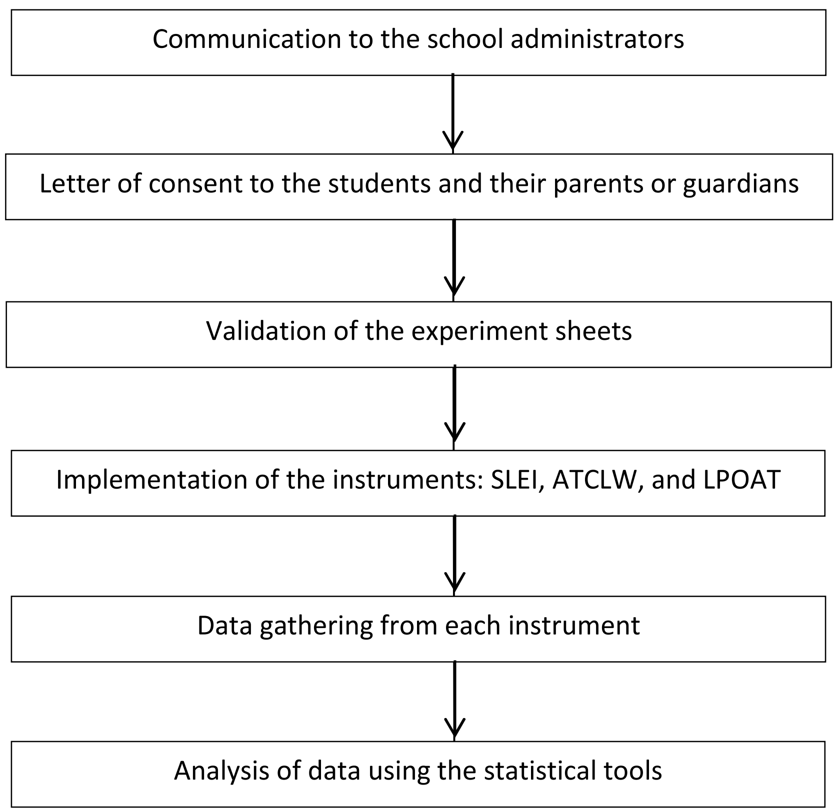

Figure 3. Research procedures

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter described the results gathered after the administration of all the necessary tools that underwent statistical evaluations.

I. Students' Attitude in Chemistry Laboratory

The attitudes of 109 students towards chemistry laboratory were determined using the Attitude Towards Chemistry Laboratory Work questionnaire adapted from Hofstein et al. (1976), which was a 25-structured item questionnaire composed of 5-point Likert scale. The scale ranged from strongly disagree (1) to strongly agree (5) depending on the students' agreement to the given description about the chemistry laboratory. The statements were a combination of positive and negative statements classified into: interest, enjoyment, practicality, way of learning, and value. The collected data was tabulated and underwent a descriptive statistics of mean and ranking to identify the common attitudes of students toward chemistry laboratory. The result of the descriptive analysis of the questionnaire is presented in Table 2.

Table 2

Mean Scores and Standard Deviation of the Domains of Students' Attitude Towards Chemistry Laboratory

Domain	Mean	SD	Rank	Remark
1. Interest	4.61	0.63	1	Strongly agree
2. Enjoyment	4.59	0.61	2	Strongly agree
3. Practicality	4.30	0.81	4	Agree
4. Way of Learning	4.25	0.81	5	Agree
5. Value	4.49	0.75	3	Agree

Students' attitude towards chemistry laboratory involved their interest in performing an experiment, enjoyment while performing an experiment, environmental value, practical aspect of an experiment, and laboratory experiment as a way of learning. Students strongly agreed that chemistry experiment was interesting as they found enjoyment working in the laboratory. Students agreed that there was a value in performing chemistry experiment and considered it as a more practical way of learning chemistry than any other forms of classroom instruction.

a. Students' Attitude in Chemistry Laboratory: Interest

Table 2.1 describes students' interest in performing chemistry experiments.

Table 2.1

Mean Scores and Standard Deviation of the Facets of Students' Interest Towards Chemistry Laboratory Experiment

Facet	Mean	SD	Rank	Remark
1. Performing experiments in chemistry makes me more interested in the subject	4.77	0.54	1	Strongly agree
2. Learning chemistry without experiments is uninteresting.	4.54	0.70	3	Strongly agree
3. Chemistry experiments are very motivating.	4.63	0.59	2	Strongly agree
4. The more time I spend on chemistry experiments, the greater my interest becomes.	4.49	0.66	4	Agree
OVERALL	4.61	0.63	---	Strongly agree

With a mean score of 4.77, the table shows that students having a strong agreement towards the idea that performing chemistry experiments increased their interest in learning chemistry. Similarly, they strongly agreed that they were motivated in executing chemistry experiments (4.63) and without it; learning chemistry would be uninteresting (4.54). There was also an agreement found between the students and the idea that their interest became greater when they spend more time in conducting chemistry experiments (4.49). These similar results were also found in the work of Abdullah et al. (2008) and further suggested that students would exhibit the same attitudes towards chemistry laboratory regardless of the type of experimentation used. Interest in a subject is vital to the cognitive learning of students. In fact, students who were not interested in studying science gave less effort in learning and understanding the concepts being taught (Hofstein & Mamlok-Naaman, 2011).

b. Students' Attitude in Chemistry Laboratory: Enjoyment

The enjoyment of students in performing chemistry experiments is described in Table 2.2.

Table 2.2

Mean Scores and Standard Deviation of the Facets of Students' Enjoyment Towards Chemistry Laboratory Experiment

Facet	Mean	SD	Rank	Remark
1. Experiment in chemistry is exciting and lively.	4.83	0.38	1	Strongly agree
2. I enjoy seeing things for myself during experiments.	4.64	0.67	4	Strongly agree
3. I enjoy handling equipment and chemicals.	4.52	0.65	5	Strongly agree
4. Performing chemistry experiments is easy for me.	4.48	0.54	6	Agree
5. I am looking forward to the next chemistry experiment.	4.74	0.55	2	Strongly agree
6. I prefer chemistry experiment than the lessons given by the teacher because chemistry experiment is organized.	4.69	0.48	3	Strongly agree
7. I like chemistry experiments because the observations and results vary.	4.23	0.75	7	Agree
OVERALL	4.59	0.61	---	Strongly Agree

The most dominant aspect of students' enjoyment was their excitement in conducting chemistry experiments having a descriptive mean score of 4.83. This was followed by their anticipation towards the next chemistry experiment (4.74). Students strongly agreed that performing chemistry experiment was way better in learning the lesson than having the same lesson to be taught in classroom because they enjoy seeing things (4.64) and handling chemicals on their own (4.52). In order to create a meaningful learning, students must experience hands-on activities that engage both their mind and hands (Bross, 2008).

c. Students' Attitude in Chemistry Laboratory: Practicality

Students' responses for the third domain (practicality) are presented in Table 2.3. The domain of practicality evaluated how the students found experiment as a more practical way—consuming less time—of learning chemistry than any other forms of teaching instruction.

Responses for practical aspects in chemistry laboratory revealed that students believed that more time should be devoted to laboratory experiments (4.58). They were also in agreement that a chemistry experiment was not a waste of money and time since the responses for both items were 4.56 and 4.47. Students' responses also revealed that, for them, there was an importance in repeating the experiments performed by scientist in the past. Furthermore, they believed that conducting an experiment may even give a positive effect in their exams.

Table 2.3

Mean Scores and Standard Deviation of the Facets of Practicality in Chemistry Laboratory Experiment

Facet	Mean	SD	Rank	Remark
1. Performing experiments in chemistry is a waste of money.	4.56	0.64	2	Strongly agree
2. More time should be devoted to chemistry experiments.	4.58	0.71	1	Strongly agree
3. If I do many experiments myself, I will do better in the final exam.	4.02	0.84	5	Agree
4. Performing experiments are not a waste of time.	4.47	0.75	3	Agree
5. Doing the experiment myself is better than viewing videos or television which shows experiments being performed.	3.81	0.73	6	Agree
6. There is a sense in redoing experiments that scientists have done in the past.	4.39	0.85	4	Agree
OVERALL	4.31	0.81	---	Agree

d. Students' Attitude in Chemistry Laboratory: Way of Learning

Table 2.4 presents how students considered experiments as a valuable part in learning chemistry.

The result implied that students strongly agreed that they could understand and learn the lesson more if they conduct a chemistry experiment since the responses for the two items were 4.54 and 4.50. A mean score of 4.33 and 4.29 indicated that students preferred laboratory work than reading chemistry books likewise, the studentsbelieved that it may be hard for them to learn and understand chemistry if there is an absence of a laboratory experiment. A number of literatures suggest that as students work to explore scientific phenomenon, science laboratories and all its aspects become unique environments that may contribute in understanding the subject (Hofstein & Lunetta, 2004; Kurbanoglu & Akin, 2010).

Table 2.4

Mean Scores and Standard Deviation of the Facets of Chemistry Laboratory Experiment as a Way of Learning

Facet	Mean	SD	Rank	Remark
1. I prefer doing experiments myself than to watch the teacher demonstrate them.	3.46	0.66	6	Maybe
2. I learn more when I do the experiment myself.	4.50	0.60	2	Strongly agree
3. I prefer doing experiments than reading my chemistry book.	4.29	0.80	5	Agree
4. Chemistry can be learned and understood with experiments.	4.38	0.70	3	Agree
5. I understand basic concepts better when I perform the experiment myself.	4.33	0.76	4	Agree
6. Performing experiments help me understand concepts better.	4.54	0.79	1	Strongly agree
OVERALL	4.25	0.81	---	Agree

Having a mean score of 3.46 for the first item indicated that, in general, the Grade 10 female students seemed to be uncertain that they would prefer to do the experiment by themselves than it to be demonstrated by their teacher. This might be due to the fact that all the experiments in the study used chemicals such as hydrochloric acid, sodium hydroxide, sulfuric acid, and ferric chloride. Ozden (2008) claimed that females fear chemicals because they believe that these are harmful to them. Similarly, Kaya and Yildirim (2014) claimed that the fear of students in carrying out laboratory experiment was the lack of feeling safe for themselves.

e. Students' Attitude in Chemistry Laboratory: Value

Students' attitude towards chemistry laboratory in terms of its value was about whether or not students found relevance in performing chemistry experiments in terms of life applications and problem solving. The summary of its data is presented on Table 2.5.

Table 2.5

Mean Scores and Standard Deviation of the Facets ofValue of Chemistry Laboratory Experiments

Facet	Mean	SD	Rank	Remark
1. With the help of experiments, chemistry comes to life.	4.49	0.92	2	Agree
2. Doing chemistry experiments helps me apply chemistry knowledge in solving problems.	4.50	0.54	1	Strongly Agree
OVERALL	4.50	0.75	---	Strongly Agree

The final part of the survey described the value of chemistry experiment. The data suggested that students strongly agreed that chemistry experiments could help them in applying their learning in solving problems since the mean score on this item was 4.50. The finding was in line with the idea of Martin (2000) stating that learning in the laboratory teaches students not only to find the correct solution to a problem but also understand the importance of experiencing the precise process in finding a solution. Furthermore, with a mean score of 4.49, students agreed that with the aid of experiments, their chemistry subject came to life.

II. Students' Perceived Laboratory Environment

The perceived laboratory environment of the students in chemistry laboratory was determined using the Science Laboratory Environment Inventory adapted from Fraser et al. (1993), which was a 35-structured item questionnaire composed of rating scales on how often students would want to see certain practices during chemistry experiment. The scale ranged from always (1) to almost never (5) depending on the student' likeness to observe the given situation as they perform their experiment in chemistry laboratory. The students' perceived laboratory environment involved in the questionnaire was classified according to Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. The result of the descriptive analysis of the questionnaire is presented in Table 3.

Table 3

Mean Scores and Standard Deviation of the Domains of Students' Perceived Laboratory Environment

Domain	Mean	SD	Rank	Remark
1. Student Cohesiveness	4.48	0.72	3	Agree
2. Open-endedness	3.58	0.85	5	Agree
3. Integration	3.80	0.80	4	Agree
4. Rule Clarity	4.53	0.70	1	Strongly Agree
5. Material Environment	4.50	0.81	2	Strongly Agree

Students' perceived laboratory environment was composed of rule clarity, material environment, student cohesiveness, integration, and open-endedness. Based on Table 3, students' perception towards their laboratory was concentrated more on the clarity of rules given by the teacher since the mean score on this item was 4.53. Students, perceived their laboratory room to have adequate supply of materials whenever they conduct an experiment. They also perceived their laboratory experiments to cater cohesiveness, relatedness to their topics in chemistry, and freedom to choose their own method of experimentation. The same results were also found in the study conducted by Olubu (2015) wherein chemistry students perceived their laboratory activities to accommodate all the five domains of a student-friendly chemistry laboratory at all times.

a. Students' Perceived Laboratory Environment on Student Cohesiveness

Table 3.1 presents the students' perceptions in terms of student cohesiveness. Student cohesiveness determined how the students would learn together as a group to ensure collaboration while conducting an experiment.

Table 3.1

Mean Scores and Standard Deviation of the Facets of Perceived Student Cohesiveness in Chemistry Laboratory

Facets	Mean	SD	Rank	Remark
1. Students in this laboratory class get along well as a group.				
2. Students have chances to get to know each other in this laboratory class.	4.15	0.78	6	Agree
3. Members of this laboratory class help one another to accomplish the assigned task.	4.94	0.25	1	Strongly Agree
4. Students in this laboratory class get to know each other well.	4.55	0.62	3	Strongly Agree
5. Students are able to depend on each other for help during laboratory classes.	4.09	0.80	7	Agree
6. It takes just a moment to get to know everybody by her first name in this laboratory.	4.40	0.84	4	Agree
7. Students work cooperatively in laboratory sessions.	4.34	0.74	5	Agree
OVERALL	4.48	0.72	---	Agree

Student cohesiveness identified the students' learning as a group and cooperativeness while conducting an experiment. Students' responses of 4.94, 4.86, and 4.55 indicated that they strongly agreed that members from their group would help one another to accomplish the assigned task. Students perceived that this would lead to familiarity with one another. Cohesiveness as a group is an important aspect of group work. Akinbobola (2015) claimed that working cooperatively develops appropriate behavior in doing work, better study habits, and drives students to ask questions that lead to social interaction and better retention of knowledge.

b. Students' Perceived Laboratory Environment on Open-Endedness

Open-endedness evaluated the nature of the experiments wherein students could freely use a method of experimentation they would prefer to accomplish the objectives of the experiment. Table 3.2 summarizes their responses.

Table 3.2

Mean Scores and Standard Deviation of the Facets of Perceived Open-Endedness in Chemistry Laboratory

Facets	Mean	SD	Rank	Remark
1. In this laboratory class, students are required to design our own experiments to solve a given problem.	3.66	0.76	3	Agree
2. During laboratory class, different students collect different data for the same problem.	3.61	0.87	4	Agree
3. Students are allowed to go beyond the regular laboratory exercise and do some experimenting of their own.	3.26	0.69	7	Maybe
4. In our laboratory sessions, different students are allowed to do different experiments.	3.73	0.82	2	Agree
5. In our laboratory sessions, the teacher does not decide the best way to carry out the laboratory experiments.	3.38	0.66	5	Maybe
6. Students decide the best way to proceed during laboratory experiments.	3.28	0.92	6	Maybe
OVERALL	3.59	0.85	---	Agree

Open-endedness emphasized an open-ended, non-traditional, non-stereotype, divergent approach to science experiments. The responses of the students could be found in between 4.18 and 3.26, which were the lowest compared to other domains. The result may suggest that students were indecisive whether or not they prefer a type of laboratory activity that would lack structure and with less supervision. In their study, Bolong, Makinda, and Saad (2014) concluded that though open-ended laboratory style had proven its effect in increasing students' achievement and outcomes, students would still give less favorable preference to this form of experimentation. Furthermore, they also suggested that this negative perception could be attributed to students' difficulty in understanding the concept and correlating the results to the hypothesis on their own because, in turn, it will require them to exert more work and effort when exposed to an open-ended laboratory. In general, the results may also suggest students' inclination to traditional, expository, close-ended style of laboratory (cook-book style) because it assures them the completeness of task by merely following the pre-determined procedures accompanied by close monitoring of the teacher.

c. Students' Perceived Laboratory Environment on Integration

Table 3.3 shows the responses of students' perceived laboratory environment in terms of integration that assessed whether scientific theory learned in class would be incorporated during laboratory experiments.

Table 3.3

Mean Scores and Standard Deviation of the Facets of Perceived Integration in Chemistry Laboratory

Facet	Mean	SD	Rank	Remark
1. The laboratory work is related to the topics that students are studying in science class.	3.97	0.81	2	Agree
2. Regular science class work is integrated with our laboratory activities.	3.56	0.67	6	Agree
3. Students use the theory from regular science class sessions during laboratory activities.	3.82	0.90	3	Agree
4. The topics covered in regular science class work are the same from topics dealt with in laboratory sessions.	3.51	0.68	7	Agree
5. What students do in laboratory sessions help them to understand the theory covered in regular science classes.	3.78	0.77	5	Agree
6. Laboratory work and regular science class work are related.	4.15	0.73	1	Agree
OVERALL	3.80	0.80	---	Agree

Table 3.3 shows that students agree that integration would be part of their laboratory experiments since the responses ranged from 4.15 to 3.51. Students perceived that laboratory experiment was not a stand-alone part of studying chemistry but an essential part of learning chemistry. Likewise, students also expected that the topics learned in their regular class would be the same topics covered during laboratory experiments. With this, it suggests that teachers must always observe integration or relatedness between topics in regular classes and laboratory sessions. This idea was in line with the idea of Cetinkaya and Cakiroglu (n.d.) that an increase in the inclusion of science theory in laboratory experiments causes increase in students' conceptual understanding that may lead to better performance and gain of valuable scientific insights.

d. Students Perceived Laboratory Environment on Rule Clarity

Table 3.4 displays the responses of students for the items in rule clarity. Rule clarity was a perceived indicator of student's agreement in performing chemistry experiments where directions and procedures to be carried out were clear and well defined before conducting the experiment.

Table 3.4

Mean Scores and Standard Deviation of the Facets of Perceived Rule Clarity in Chemistry Laboratory

Facet	Mean	SD	Rank	Remark
1. This laboratory class is rather formal and adequate rules are imposed.	4.14	0.85	7	Agree
2. Students are required to follow certain rules in the laboratory.	4.57	0.70	3	Strongly Agree
3. There is a recognized way of doing things safely in this laboratory.	4.68	0.59	2	Strongly Agree
4. There are sufficient rules for students to follow in laboratory sessions.	4.53	0.62	4	Strongly Agree
5. The teacher outlines safety precautions before laboratory sessions commence.	4.49	0.73	6	Agree
6. This laboratory class runs under clear rules.	4.79	0.49	1	Strongly Agree
OVERALL	4.53	0.70	---	Strongly Agree

Rule clarity, having an overall mean score 4.53, indicated students' agreement in performing chemistry experiments wherein directions and procedures to be carried out were clear and well defined. Students perceived their chemistry laboratory would ran under clear rules that all students were required to follow in order safeguard their well-beings since the responses of the students in those items were 4.79, 4.68, and 4.57. Clarity of rules is an important factor to consider before starting an experiment. It guarantees students' safety as they carry out tasks involving proper handling and care of materials and equipment (Akinbobola, 2015). In school science laboratories, one of the leading sources of accidents are students who fail to give careful consideration to what they do, having no complete understanding on the complexity of work, and improper execution of procedures. This is in line with the findings of Aliyu (n.d.) that the most common sources of accidents in science laboratories are lack of knowledge, lack of control, lack of seriousness, lack of the right attitude, and unfamiliarity to equipment.

e. Students Perceived Laboratory Environment on Material Environment

The availability of the laboratory materials and appearance of the laboratory as perceived by the students were identified through material environment. The result of the responses of the students is presented on Table 3.5.

Table 3.5

Mean Scores and Standard Deviation of the Facets of Perceived Material Environment in Chemistry Laboratory

Facets	Mean	SD	Rank	Remark
1. The laboratory has enough space when students are doing experiments.	3.86	1.33	7	Agree
2. The equipment and materials that students need for laboratory activities are readily available.	4.61	0.61	4	Strongly Agree
3. Students are proud of the appearance of this laboratory.	4.64	0.60	3	Strongly Agree
4. Laboratory equipment is in good working order.	4.70	0.46	1.5	Strongly Agree
5. The laboratory is well ventilated	4.49	0.74	6	Agree
6. The laboratory is an attractive working place.	4.53	0.67	5	Strongly Agree
7. The laboratory is enough for either individual or group work.	4.70	0.65	1.5	Strongly Agree
OVERALL	4.50	0.81	---	Strongly Agree

Material environment received an affirmative result for the perceived dimension of students in laboratory environment having an overall descriptive mean score of 4.50. Students perceived their chemistry laboratory to have sufficient supply of materials and equipment that were in good-working conditions since the responses of the students were both 4.70 for the two items. To have readily available materials and equipment in laboratory lead to better concentration in performing task and facilitation of learning. This is in line with the idea of Kalu (2004) that conducting laboratory activities with ample number of manipulative materials and equipment can improve students' scientific understanding of concepts and principles as well as the nature of science. Similarly, having an adequate number of materials in laboratory improves familiarity in handling laboratory apparatus and develops proper execution laboratory skills. Having a good laboratory allows the students to enrich their manipulative and science process skills that help them deal with problems (Fraser, 1995 as cited by Akinbobola, 2015).

III. Students' Laboratory Performance Skills

The laboratory performance skills of students in chemistry laboratory were determined using the Laboratory Performance Observation Assessment Tool adapted from Calamlam (2013), which was an 11-component rubric composed of a 4-point scoring guide: 4 points being the highest score and 1 point for the lowest. The rubric identified and described the various laboratory performance skills elicited by the students such as preparation, collaboration, task management, and communication skills. The students were observed during their chemistry laboratory classes by the researcher, together with two other chemistry teachers. The collected data was tabulated and underwent a descriptive statistics of mean, percentage rating, and ranking. The results of the descriptive analysis are presented in Table 4.

Table 4

Mean Scores and Standard Deviation of the Components of Students' Laboratory Performance Skills

Component	Mean	SD	Rank	Remark
I. Experimental procedures	3.17	0.70	8	Often
II. Physical preparation	3.94	0.25	1	Always
III. Laboratory techniques	2.66	0.61	11	Often
IV. Collaboration and leadership	2.89	0.85	9	Often
V. Task management	3.31	0.78	6	Often
VI. Safety procedures	3.87	0.34	3	Always
VII. Oral communication	3.43	0.50	5	Often
VIII. Organization and set-up	3.26	0.61	7	Often
IX. High quality results	2.68	0.47	10	Often
X. Time management	3.47	0.73	4	Often
Housekeeping	3.89	0.31	2	Always

Based on the descriptive statistical analysis of the gathered results, it was observed that students always exhibited physical preparation for all the experimental sessions conducted during the course of this study since the mean score on this component was 3.94. Students were able to show their preparedness by wearing complete and appropriate laboratory attire (lab gowns, goggles, and gloves) at the start of the experiment that implied students' awareness of their accountability, responsibility and self-direction before conducting laboratory experiment.

Students' liability and responsibility in maintaining cleanliness in their workplace during an experiment were evident throughout this study. Having a mean score of 3.89 in terms of housekeeping indicated that they were able to keep their table neat and the materials used were washed thoroughly and returned properly after the experiment. It was also observed that no accident was reported during the course of the experiment which was reflected on the remark of the evaluators to students' observation of safety procedures having a mean score of 3.87.

Other notable laboratory performance skills observed to students were time management, oral communication especially during the analysis of results, dissemination and execution of respective tasks or task management, orderliness and organization, preparedness on experimental procedures, collaboration and leadership, producing high quality results of the experiment, and proper execution of some laboratory techniques—proper handling of chemicals and equipment, using the analytical balance, graduated cylinder, and Bunsen burner correctly, and transferring of chemicals.

IV. Differences in Students' Laboratory Performance Skills by Attitude towards Chemistry Laboratory

Table 5 presents the analysis on significant difference in students' laboratory performance skills by their attitude towards chemistry laboratory using an alpha level of .05 for the statistical test.

Table 5

Difference in Student's Laboratory Performance Skills by Attitude towards Chemistry Laboratory

Domain	*%*	$\overline{X}$	*SD*	*DF*	*F*	*p-level*	Remark
1. Interest	74.31	3.297	0.352	1, 107	4.210	0.043	*Significant*
	25.69	3.399	0.241				
2. Enjoyment	60.55	3.357	0.314	1, 107	3.966	0.049	*Significant*
	39.45	3.273	0.347				
3. Practicality	49.54	3.290	0.384	2, 106	4.100	0.019	*Significant*
	42.20	3.358	0.246				
	8.26	3.354	0.330				
4. Way of Learning	39.45	3.285	0.366	2, 106	4.612	0.012	*Significant*
	54.13	3.336	0.310				
	6.42	3.455	0.182				
5. Value	72.48	3.312	0.342	2, 106	3.227	0.044	*Significant*
	22.02	3.337	0.308				
	5.50	3.424	0.214				
Composite	42.20	3.298	0.379	2, 106	4.590	0.012	Significant

N=109, p<.05

A one-way between subjects ANOVA was conducted to compare the effect of students' attitudes towards chemistry laboratory—interest, enjoyment, practicality, way of learning, and value—in their laboratory performance skills. The result shows that there was a significant effect of students' attitude towards chemistry laboratory on laboratory performance skills at the $p<.05$ level for the five domains [$F(2, 106) = 4.590$, $p = 0.012$]. The analysis of results showed that the laboratory performance skills of the students significantly differ according to their attitude towards their chemistry laboratory that included their interest ($p = 0.043$), enjoyment ($p = 0.049$), practicality ($p = 0.019$), way of learning ($p = 0.012$), and value ($p = 0.044$) on laboratory experiments.

V. Differences in Students' Laboratory Performance Skills by Perceived Laboratory Environment

Table 6 presents the analysis on significant difference in students' laboratory performance skills by their perception on their laboratory environment using an alpha level of .05 for the statistical test.

A one-way between subjects ANOVA was conducted to compare the effect of students' perceived laboratory environment—student cohesiveness, open-endedness, integration, rule clarity, and material environment—in their laboratory performance skills. The result shows that there was a significant effect of students' perception towards chemistry laboratory on laboratory performance skills at the $p<.05$ level ($F(2, 106) = 3.954$, $p =0.022$].

Furthermore, the analysis of results shows that the laboratory performance skills of the students significantly differ according to their perception towards their chemistry laboratory that included student cohesiveness ($p = 0.004$), rule clarity ($p = 0.022$), and material environment (0.034). There were no significant differences found on students' perception in terms of open-endedness and integration to their laboratory performance skills.

Table 6

Difference in Student's Laboratory Performance Skills by Perceived Laboratory Environment

Domain	%	$\overline{X}$	*SD*	*DF*	*F*	*p-level*	Remark
1. Student Cohesiveness	55.96	3.404	0.260	1, 107	8.715	0.004	*Significant*
	44.04	3.222	0.378				
2. Rule Clarity	57.80	3.364	0.306	2, 106	3.941	0.022	*Significant*
	39.45	3.290	0.357				
	3.67	3.045	0.187				
3. Material Environment	50.46	3.347	0.296	1, 107	4.600	0.034	*Significant*
	49.54	3.300	0.360				
Composite	6.42	3.377	0.203	2, 106	3.954	0.022	*Significant*

N=109, $p<.05$

VI. Correlation between Students' Attitudes towards Chemistry Laboratory and Laboratory Performance Skills

The measures of statistical significance of associations using Pearson-r moment correlation at alpha level .05 between students' attitude towards chemistry laboratory and their laboratory performance skills are presented in Table 7.

Based on the analysis of results in Table 7, there was a significant correlation of 0.206 (p = 0.560) between students attitude and performance skills in chemistry laboratory. There was also a significant correlation of 0.216 (p=0.031) between students' laboratory experimental procedure and attitude towards chemistry laboratory. Attitude and safety procedures were moderately significantly correlated, *r* = 0.377, *p*<.05. Similarly, significant correlations were found from performance skills in terms of oral communication (*r* = 0.299), organization and set-up (*r* = *0*.205), and task management (*r* = 0.230) to students' attitude towards chemistry laboratory. A significant correlation was also found between students' laboratory performance skills and their considerations that experiments were part of learning chemistry, *r* = *0*.211, and a more practical way of learning the subject (*r* =*0*.239).

Table 7

Correlation Between Laboratory Performance Skills and Attitude towards Chemistry Laboratory

Component	Interest	Enjoyment	Practicality	Way of Learning	Value	Attitude towards Chemistry Laboratory Composite
I. Experimental procedures	0.058	0.145	*0.195**	0.090	0.128	*0.216**
II. Physical preparation	0.103	*0.233**	0.129	0.040	*0.217**	0.068
III. Laboratory techniques	0.019	0.060	0.146	*0.276**	*0.199**	0.101
IV. Task management	0.137	0.016	0.*299**	*0.305***	0.114	*0.230**
V. Safety procedures	0.103	*0.334***	0.129	*0.249***	*0.217**	*0.377***
VI. Oral communication	0.020	0.109	*0.461***	0.046	0.042	*0.299**
VII. Organization and set-up	*0.288**	0.057	0.860	*0.307***	0.150	*0.205**
VIII. Time management	0.055	*0.192**	*0.259**	0.008	0.116	0.174
Laboratory Performance Skills Composite	0.065	0.038	*0.239**	*0.211**	0.059	*0.206**

* Low significance at p<.05
**Moderate significance

VII. Correlation between Students' Perceived Laboratory Environment and Laboratory Performance Skills

Table 8 presents the analysis of correlation using Pearson-r to determine the direction and strength of relation at .05 alpha levels between students' perceived laboratory environment and performance skills in chemistry laboratory.

Table 8

Correlation Between Laboratory Performance Skills and Perceived Laboratory Environment

Component	Student Cohesiveness	Open-endedness	Integration	Rule Clarity	Material Environment	Perceived Laboratory Composite
I. Experimental procedures	0.358**	0.071	0.240*	0.592***	0.206*	0.489**
II. Physical preparation	0.204*	0.335**	0.129	0.194*	0.296*	0.351**
III. Laboratory techniques	0.189*	0.326**	0.113	0.428**	0.087	0.241*
IV. Collaboration and leadership	0.015	0.400**	0.068	0.431**	0.134	0.118
V. Task management	0.225*	0.023	0.242*	0.506***	0.018	0.220*
VI. Safety procedures	0.297*	0.234*	0.297*	0.109	0.407**	0.272*
VII. Organization and set-up	0.469**	0.310**	0.037	0.298	0.073	0.467**
VIII. High quality results	0.275*	0.056	0.070	0.200*	0.020	0.191*
IX. Time management	0.367**	0.201*	0.027	0.083	0.126	0.083
X. Housekeeping	0.436**	0.139	0.423**	0.222*	0.219*	0.221*
Laboratory Performance Skills Composite	0.414**	0.085	0.101	0.538***	0.115	0.385**

* Low significant correlation at p<.05
**Moderate significant correlation
***High significant correlation

Results indicate that, at .05 alpha level, students' perceived laboratory environment and laboratory performance skills were moderately positively correlated, $r = 0.385$. Similar result was found in the studies of Awang (2013) and Olubu (2015) on how learning environment contributes to the performance of the students. Furthermore, the researchers suggested that students' learning environment perceptions may significantly help the teachers to identify the possible outcomes of students' understanding of the activity.

A moderate significant correlation between students' perceived laboratory environment and performance skills in terms of experimental preparation (r = 0.489), physical preparation (r = 0.351), and organization and set-up (r = 0.467). Student' perception has a significant correlation to their execution of laboratory techniques, r = 0.241. The same correlations were also observed to their perception and task management (r = 0.220), observation of safety procedures (r = 0.272), production of high quality results (r = 0.191), and housekeeping (r = 0.221). The results also presented that students' performance skills in chemistry laboratory has a moderate correlation with their perceived student cohesiveness, r =0.414, while having a highly significant correlation with rule clarity, r = 0.538.

VIII. Regression Analysis between Laboratory Performance Skills and Attitude towards Chemistry Laboratory

To estimate the relationship existed between laboratory performance skills and students' attitude towards chemistry laboratory, the standardized regression coefficients, β, were determined. Table 9 presents the result of the analysis.

Table 9

Standardized Regression Coefficient: Laboratory Performance Skills by Attitude towards Chemistry Laboratory

Component	Interest	Enjoyment	Practicality	Way of Learning	Value	Attitude towards Chemistry Laboratory Composite
I. Experimental procedures	0.058	0.145	*0.195**	0.090	0.128	*0.216**
II. Physical preparation	0.103	*0.233**	0.129	0.040	*0.217**	0.068
III. Laboratory techniques	0.019	0.060	0.146	*0.276**	*0.199**	0.101
IV. Task management	0.137	0.016	0.*299**	*0.305***	0.114	0.230*
V. Safety procedures	0.103	*0.334***	0.129	*0.249***	*0.217**	*0.377***
VI. Oral communicatio n	0.020	0.109	*0.461***	0.046	0.042	*0.299**
VII. Organization and set-up	*0.288**	0.057	0.860	*0.307***	0.150	*0.205**
VIII. Time management	0.055	*0.192**	*0.259**	0.008	0.116	0.174
Laboratory Performance Skills Composite	0.065	0.038	0.239*	*0.211**	0.059	0.206*

* Low significance at p<.05
**Moderate significance

Students' attitude towards chemistry experiment significantly predicted performance skills' scores, β = 0.206, $t(107) = 2.180$, $p<0.031$. Students' perceived laboratory environment also explained a significant proportion of variance in performance skills' scores, $R^2 = 0.043$, $F(1, 107) = 4.752$, $p<0.031$.

Students' attitude towards chemistry laboratory in terms of practicality may predict their procedural preparation for an experiment (β=0.195). Whenever students find experiment as a more practical way of learning chemistry, they diligently prepare not only through physical preparation but also through experimental procedures. Being prepared before an experiment ensures familiarity of the procedures, awareness of what data are needed, and fluidity and continuity of the experiment that would help the students to accomplish the task on time.

Environmental value (β=0.233) and enjoyment (β=0.217) could be used to determine how students physically prepare for the experimental work. Knowing the value of an activity and how could it be applied in daily problem-solving situations give students a sense of responsibility on their learning. It helps them enjoy and appreciate what they do in the laboratory. It keeps them active throughout the activity and to prepare for it before the learning hour begins. To ensure students' full engagement to an activity, teachers must ensure to emphasize the value of what they are doing in a personal relevant way (Martin, 2000).Environmental value of practical work could also predict students' execution of laboratory techniques (β=0.199). Proper execution of procedures in an experiment is motivated on how students see the significance of the task. Bandura and Schunk (1981) suggested that a meaningful activity leads to students' self-efficacy and positively affects the effective performance of the activity.

The results also showed that whenever students consider experiment as a valuable part of learning the topic, students give importance while doing the experimental work. This involved their task management or spontaneity in executing the procedures (β=0.305), observance of safety during the experiment (β=0.249), and observing order in terms of materials and equipment (β=0.307).When students find experiments as a more effective and better way of learning chemistry, they can focus more on the things they do and effectively engage on the task at hand.

Ensuring that students find practicality in laboratory experiment could enhance students' skills in task management (β=0.259) and communication within the group (β=0.461). When activities are relevant to student's life, the culture of learning improves (Parsons & Taylor, 2011). The idea could suggest that life-engaging experiments help develop positive engagement in the activity through an active sharing of thoughts and better execution of tasks at hand. In an almost similar manner, when students considers an experiment as part of the learning process and not just a follow-the-steps activity (Hofstein & Lunneta, 2004; Hart et al., 2000; Reid& Shah, 2007), they tend to work efficiently and, in turn, finish the experiment before the given allotted time.

The results also indicated the components of laboratory performance skills that could be predicted by students' over-all perception towards chemistry experiment, which included planning for experimental procedures (β = 0.216), task management (β = 0.230), observation of safety procedures (β = 0.377), oral communication (β = 0.299), and laboratory organization and set-up (β = 0.205).

IX. Regression Analysis between Laboratory Performance Skills and Perceived Laboratory Environment

The standardized regression coefficients, β, found in Table 10 were identified to show if students' perceived laboratory environment could be used to predict their laboratory performance skills during chemistry experiments.

Table 10

Standardized Regression Coefficient: Laboratory Performance Skills by Perceived Laboratory Environment

Component	Student Cohesiveness	Open-endedness	Integration	Rule Clarity	Material Environment	Perceived Laboratory Composite
I. Experimental procedures	0.358**	0.071	0.240*	0.592***	0.206*	0.489**
II. Physical preparation	0.204*	0.335**	0.129	0.194*	0.296*	0.351**
III. Laboratory techniques	0.189*	0.326**	0.113	0.428**	0.087	0.241*
IV. Collaboration and leadership	0.015	0.400**	0.068	0.431**	0.134	0.118
V. Task management	0.225*	0.023	0.242*	0.506***	0.018	0.220*
VI. Safety procedures	0.297*	0.234*	0.297*	0.109	0.407**	0.272*
VI. Organization and set-up	0.469**	0.310**	0.037	0.298	0.073	0.467**
VIII. High quality results	0.275*	0.056	0.070	0.200*	0.020	0.191*
IX. Time management	0.367**	0.201*	0.027	0.083	0.126	0.083
X. Housekeeping	0.436**	0.139	0.423**	0.222*	0.219*	0.221*
Laboratory Performance Skills Composite	0.414**	0.085	0.101	0.538***	0.115	0.385**

* Low significant correlation at p<.05
**Moderate significant correlation
***High significant correlation

The summarized data in Table 10 showed how students' perception could affect students' skills while performing chemistry experiment. Student's experimental preparation skill could be affected by her perceptions on how the rules are clearly set. Students can better prepare for the experiment if the guidelines and procedures were clearly stated before the start of the experiment (β=0.592). Clarity of rules make students to be aware of expectations and understand the task beforehand better. Similarly, students' physical preparation for the experiment could be determined by the clearness of the rules (β=0.194). Having clear rules at the beginning of the class or activity, create a sense of predictability of doing what is right in order to avoid consequences that will affect students' behavior and performance ("Creating and implementing effective rules," n.d.).Setting clear rules made the students to be aware on their responsibilities in complying with the requirements of the activity and to the results of misbehaving.

Students' skill in performing collaborative work with spontaneity (task management) depends on how the procedures were set with clarity (β=0.506). Rule clarity determines students' capability in effectively carrying out the task at hand. Setting clear guidelines lessen confusion to students and minimize anxiety while performing an activity. Less confusion creates a smooth transition of things in a class. When there is a presence of confusion to the expectations, it creates an environment of uneasiness to students that could lead into constraints as they conduct an experiment. Likewise, the data also showed that when rules were known to students, laboratory techniques are properly executed (β=0.428). This is in line with the findings of Akinbobola (2015) that clarity of rules ensures students' safety as they carry out tasks that involve proper handling and care of materials and equipment. Aliyu's (n.d.) study suggested that in order to avoid or lessen laboratory accidents in schools, there must be a proper orientation to the students about the rules and regulations in the laboratory. An understanding of the ground-rules fosters better communication, collaboration and leadership during laboratory activity (β=0.431). Students could effectively participate during group discussion when expectations were made clear to them. Setting clear expectations before the start of a collaborative work guides the students on what to do that in turn, ensures a harmonious relationship and coordination within the group.

Organization, orderliness and the manner on how students manage the materials during the experiment were all depended on the cohesiveness of the students (β=0.469). During laboratory experiments, when students know their own respective responsibilities, there is a sense of order within the group. This order can also become apparent on how the materials are organized and arranged. On the other hand, the way students handle the gathered data depends on the clarity of the rules (β=0.275). Setting well-defined expectations creates a clear sense of direction on what the students must do during the course of the activity in order to acquire the necessary data. Rule clarity leads to better concentration while conducting the experiment and better understanding to what students are doing.

In terms of housekeeping skill, the way students manage the cleanliness of the materials and working area during and after experiment depended on student cohesiveness (β=0.436). Familiarity on each other's task creates order and oneness within the group. When students are driven with a task-orientated laboratory activity, all the necessary things-- before, during, and after the experiment-- will all be given an attention.

Students' perceived laboratory environment significantly predicted performance skills' scores, $\beta = 0.358$, $t(107) = 4.318$, $p < .000$. Students' perceived laboratory environment also explained a significant proportion of variance in performance skills' scores, $R^2 = 0.148$, $F(1, 107) = 18.647$, $p < .000$. The results suggested that students' perception may have a significant impact on their laboratory performance skills. A multiple regression analysis of students' perceived laboratory environment and chemistry performance by Olubu (2015) gave similar results and showed how all the learning environment components significantly contributed to students' performance.

The table also shows that students' perceived laboratory environment could be used to predict specific laboratory performance skills, namely: planning for experimental procedures ($\beta = 0.489$), physical preparation for the experiment ($\beta = 0.351$), execution of laboratory techniques ($\beta = 0.241$), task management ($\beta = 0.220$), observation of safety procedures ($\beta = 0.272$), laboratory organization and set-up ($\beta = 0.467$), producing high quality results ($\beta = 0.191$), and housekeeping ($\beta = 0.221$).

X. Regression Analysis between Laboratory Performance Skills, Attitude towards Chemistry Laboratory, and Perceived Laboratory Environment

A multiple linear regression was calculated to predict students' laboratory performance skills based on their perceived laboratory environment and attitude towards chemistry laboratory. Table 11 presents the result of multiple regression analysis of laboratory performance skills by students' attitude towards chemistry laboratory and perceived laboratory environment. A significant regression equation was found ($F(2,106) = 9.506$, $p = .000$), with an R^2 of 0.152. Students' predicted performance skills were equal to 2.286 + 0.141 (attitude) + 0.225 (perception). Students' performance skills increased 0.141 and 0.225 as their attitude and perception toward chemistry laboratory increased.

Table 11

Standardized Regression Coefficient: Laboratory Performance Skills by Attitude towards Chemistry Laboratoryand Perceived Laboratory Environment

Component	Perception	Attitude
I. Experimental procedures	0.487**	0.221*
II. Physical preparation	0.351**	0.064
III. Laboratory techniques	0.242**	0.103
IV. Collaboration and leadership	0.117	0.020
V. Task management	0.220*	0.232*
VI. Safety procedures	0.268**	0.374**
VII. Oral communication	0.140	0.300**
VIII. Organization and set-up	0.469**	0.210*
IX. High quality results	0.192*	0.247**
X. Time management	0.085	0.175
XI. Housekeeping	0.220*	0.073
Laboratory Performance Skills Composite	0.386**	0.204*

* Low significant correlation at p<.05

**Moderate significant correlation

Students' attitude and perception significantly predicted the planning of experimental procedures, β = 0.221 (attitude) and 0.487 (perception), *t*(2.684, 5.916) = 0.008, .000, $p < .05$. Performance skills in terms of task management, observation of safety procedures, laboratory organization and set-up, and producing of high quality results were also found to have significant regression results with students' attitude and perception towards chemistry laboratory.

XI. Implications for Research and Practice

Over-all, the findings of this study have relevant implications for understanding how students perform during chemistry experiments. Laboratory performance skills, as mentioned in previous literatures, are vital to achieve the purpose of experimentation, which in turn, leads to learning and understanding. The results revealed that there were variations from the way students execute these skills. It was found that students have the strong awareness of their accountability, responsibility and self-direction especially before and after conducting a laboratory experiment. These findings accounted for their most evident performance skills observed which are physical preparation and housekeeping. On the other hand, it was found that students failed to produce high quality results from their experiment. This result may be concomitant with their improper execution of laboratory techniques that may suggest that close-teacher supervision is still in order to realize the completeness of the tasks.

The findings also suggested that attitude and perception affect students' performance during laboratory experiments. In general, students have found interest towards chemistry experiment, which in turn, helped in increasing their interest in studying chemistry and performing well during experiments. According to Hofstein and Naaman (2011), interest is vital to the cognitive learning of students. In fact, students who are not interested in studying science, give less effort in learning and understanding the concepts being taught. Therefore, it is a challenge to chemistry teachers to build students' interest as they perform experiments to ensure quality of performance and outcomes. Students' attitude towards chemistry experiment could predict several of their laboratory performance skills. One of these includes preparation before the experiment that may help them in preparing pre-lab journal and awareness of expected data to be gathered at the end of the experiment. When students have a favorable attitude, a sense of responsibility is set that enhances their task management, oral communication, and order in the laboratory that in turn minimize accidents and experimental errors in the laboratory.

The study also makes the case that student execution of performance skills is enhanced by clarity of rules. Clarity of rules ensures students' safety as they carry out tasks that involve proper handling and care of materials and equipment. When rules are understood by everyone, it creates a sense of predictability of doing what is supposed to be done in order to avoid consequences that will affect student's behavior and performance. On the other hand, even though an open-ended type of experiment may enhance students' oral skills, the results showed that students have an adverse inclination towards this style of experimentation. This finding may be attributed to students' unfamiliarity to this kind of experiment. Teachers may help solve this problem by creating a progressive form of conducting experiments where there is a gradual change from a 'cook-book' style of experiment to an open-ended experimentation. Close supervision of the teacher will be needed in order to monitor students' progress as changes in the style of experimentation happen.

CHAPTER V

SUMMARY OF RESULTS, CONCLUSION, AND RECOMMENDATION

After the admission of the instruments and analysis of the results, the summary of the study, conclusions, and recommendations are presented below.

Summary of Results

In this present study, the Attitude Towards Chemistry Laboratory Work (ATCLW) was employed to assess the attitude of 109 Grade 10 chemistry studentsin relation to laboratory experiments in chemistry, whilethe Science Laboratory Environment Inventory (SLEI) was used to determine students' perceptions toward their laboratory environment in chemistry. The demonstration of the laboratory performance skills was assessed using the Laboratory Performance Observation Assessment Tool (LPOAT). The collected data underwent analysis to determine relationship between students' attitudes, perceived laboratory environment, and performance skills in chemistry laboratory.

The results indicated that the attitudes of the students toward chemistry laboratory were centered into five components, namely: interest, enjoyment, value, practicality, and way of learning. The findings of the study also revealed that students' interest in doing laboratory experiment was the most favorable component of students' attitude while 'way of learning' was the least favorable. On the other hand, students' perceptions towards their chemistry laboratory classes focused on the clarity of rules, availability of materials, student cooperation, integration, and open-endedness. The results also revealed that rule clarity was the most favorable component of chemistry laboratory environment while open-endedness was found to be the least among the five components.

One-way analysis of variance showed that significant difference within laboratory performance skills according to students' attitude and perception towards chemistry laboratory was present among students. The correlation analysis showed a positive correlation between attitude towards chemistry laboratory and performance skills. Similarly, a positive correlation was also found between students' perception of laboratory environment and performance skills. Rule clarity and student cohesiveness showed the most favorable correlations to students' performance skills. Regression analysis revealed that attitude and perception were significant predictors of students' laboratory performance skills.

Conclusions

The study focused on determining the relationship between students' perceived laboratory environment, attitude towards chemistry laboratory, and laboratory performanceskillsin chemistry. After gathering and analyzing the necessary information, the following ideas were concluded:

1. Students have varying attitudes, perceptions, and performance skills in chemistry laboratory.
2. There was a significant difference in students' laboratory performance skills when they were categorized according to their attitude towards chemistry experiment and perceived science laboratory environment.
3. Students' attitudes towards chemistry laboratory and laboratory performance skills were significantly correlated. Likewise, there was a significant correlation found betweenstudents' perceived science laboratory environment and laboratory performance skills.
4. Students' attitudes towards chemistry laboratory and perceived science laboratory directly contributed to students' laboratory performance skills in chemistry. The more favorable the laboratory environment and attitude were, the more positive was the performance of laboratory skills of the students.

Recommendations

To further improve and understand the interaction of students' attitude and perception, and their effects to their laboratory performance skills, the following recommendations were suggested:

1. The development of laboratory learning materials that are practical and effective way of learning chemistry is suggested not only for the students to enjoy

performing experiments but to also improve students' attitude towards chemistry experiments.

2. Improvement of the laboratory orientation at the start of the school year to identifyand set expectations, recognize the purpose of doing experimentations, arouse students' interest in performing experiments, and establish favorable perceptions towards chemistry experiments.
3. The use of other means of classifying the students into their levels of attitude and perceived laboratory environment is recommended to determine the extent on how attitude and perception can relate to students' laboratory performance skills.
4. The study was conducted to an all-female group sample. The administration of the same study to either an all-male or mixed gender group sample is recommended to determine if gender can affect the interaction of the three variables used: attitude, perceived laboratory environment, and performance skills in laboratory.
5. The researcher also recommends that the same study be conducted to other grade level and topics in chemistry to check whether or not the same set of results will be achieved.
6. The research was limited to assessing students' laboratory skills through attitude and science environment perception. Inclusion of other psychoeducational factors can be used to determine the development of the students in terms of their laboratory performance skills in chemistry.

7. The development of another method of triangulation can be done in gathering pertinent information while examining students' skills during a laboratory activity.

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APPENDIX A

EVALUATORS' PROFILE

Evaluator	Sex	Age	Highest Degree	School
1	F	41	MS Chemistry Ed.	UST
2	M	32	MS Chemistry	DLSHSI
3	M	37	MS Chemistry	PNU

APPENDIX B

CHEMISTRY LABORATORY EXPERIMENTS' INFORMATION SHEET

Experiment No.	Topic Lesson	Title	Objectives	Week No.
1	Biomolecules	Identifying Selected Biomolecules	- To test for the presence of starch, proteins, and fats in common food. - To observe and record the color reactions of various food using different testing reagents.	1
2	Law of Conservation of Mass	Law of Conservation of Mass	- To compare the mass of the reactants with the mass of the products in a reaction.	2
3	Chemical Reaction	Types of Chemical Reactions	- Identify the types of chemical reaction.	3
4	Activity Series of Metals	Reactions of Metals with Hydrochloric Acid	- To describe the reactions of different free metals with hydrochloric acid.	4
5	Properties of Gases	Identifying Properties of Gases	- To determine the properties of selected gases.	5

APPENDIX C

SAMPLE SCIENCE LABORATORY ENVIRONMENT INVENTORY

Class No. ______
*Section*______________________________

Directions: This questionnaire contains statements about practices that you would like to be implemented in this class. There are no correct or incorrect responses. Read each item carefully. Think about how well each statement describes what your preferred laboratory class *would look like*. For each sentence, check (✓) the box corresponding to your response.

Scale	Description
5	*I like to almost never see this takes place in our chemistry class.*
4	*I like to seldom see this takes place in our chemistry class.*
3	*I like to sometimes see this takes place in our chemistry class.*
2	*I like to often see this takes place in our chemistry class.*
1	*I like to always see this takes place in our chemistry class.*

For example:

Statement	5	4	3	2	1
Students in this laboratory class get along well as a group.	✓				

If you think that you would want to see a laboratory class where students get along with one another, always, check the box under the 1. If you almost never want to see this, check the 5. You also can choose the numbers 4, 3 and 2 which are in-between.

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements. Thank you for your cooperation!

Item No.	Statement	5	4	3	2	1
1	Students in this laboratory class get along well as a group.					
4	Students' laboratory class has clear rules to guide student activities.					
9	This laboratory class is rather informal and few rules are imposed.					

APPENDIX D

SAMPLE ATTITUDE TOWARDS CHEMISTRY LABORATORY WORK

Class No. ______
*Section*___________________________

Directions: This inventory consists of statements about your attitude toward chemistry experiments. There are no correct or incorrect responses. Read each item carefully. Think about how you feel about each item. For each sentence, check (✓) the box corresponding to your response.

Scale	Description
5	*I strongly disagree with the statement about the chemistry experiment.*
4	*I disagree with the statement about the chemistry experiment.*
3	*I am not sure if I will agree or disagree with the statement about the chemistry experiment.*
2	*I agree with the statement about the chemistry experiment.*
1	*I strongly agree with the statement about the chemistry experiment.*

For example:

	5	4	3	2	1
Performing experiments in chemistry increases my interest in the subject.					✓

If you **strongly disagree** that performing an experiment can increase your interest in chemistry, **check the box under the 5.** If you **strongly agree,check the 1.** You also can choose the **numbers 4, 3 and 2 which are in-between**. If you want to change your answer, cross it out and check a new number. Thank you for your cooperation.

Item no.	Statement	5	4	3	2	1
1	Performing experiments in chemistry makes me more interested in the subject.					
7	I learn more when I do the experiment myself.					
9	I prefer reading my chemistry book than doing experiments.					
14	I understand basic concepts better when I perform the experiment myself.					
20	The more time I spend on chemistry experiments, the greater my interest becomes.					

APPENDIX E

SAMPLE LABORATORY PEFORMANCE OBSERVATION ASSESSMENT TOOL

Criteria/Components	4 pts.	3 pts.	2 pts.	1 pts.	Ratings		
					Exp 1	Exp 2	Exp 3
1. Planning the experimental procedures	• All the steps in the diagram are correctly connected and sequenced. • Connectors between the steps are unambiguous.	• 1 to 2 steps are misplaced, lacking, incorrectly connected or incorrectly sequenced.	• 3 steps are misplaced, lacking, incorrectly connected or incorrectly sequenced.	• 4 or more steps are misplaced, lacking, incorrectly connected or incorrectly sequenced.			
7. Professionalism: oral communication between group members with others	• Communication between members is only audible within the group most of the time. • Professional language is always used during conversation.	• Communication between members is only audible within the group most of the time. • Professional language is always used during conversation. •	• Communication is audible to the other group although minimal. • Professional language is seldom used during conversation. • Noise and unnecessary movement occurred and reminders from the instructor are still needed.	• Communication between the members can disturb other group. • Professional language is not used during conversation. • There are noise and unnecessary movements. • Constant reminders from the instructor are still needed.			

APPENDIX F

SAMPLE LABORATORY EXPERIMENT SHEET

St. Scholastica's Academy, Marikina
HS Department
CHEMISTRY

EXPERIMENT

3

Group No.: ………………….. Score: ………..

Class Nos.: ………………………………. Date:

Gr&Sec.: ……………………………………………

Types of Chemical Reaction

I. OBJECTIVE

Identify the types of chemical reaction.

II. SAFETY PRECAUTIONS

- Keep combustible or flammable materials away from an open fire.
- Always wear gloves in handing chemicals.

III. MATERIALS

Magnesium ribbon
Copper turnings

Mossy zinc
Iron filings
Calcium carbonate ($CaCO_3$)
Sodium hydroxide solution (NaOH)

Copper (II) sulfate solution ($CuSO_4$)
Silver nitrate solution ($AgNO_3$)
Barium chloride solution ($BaCl_2$)
Sulfuric acid solution (H_2SO_4)
Hydrochloric acid, HCl (diluted and concentrated)

Test tube
Test tube rack
Test tube holder
Crucible tong
Graduated cylinder
Bunsen burner
Splint
Spatula
Funnel

IV. PROCEDURES

1. Hold a piece of magnesium ribbon using a crucible tong or a test tube holder and ignite using the flame of the burner. Observe.
2. Heat a spatula of $CaCO_3$in a test tube. While heating, insert a glowing splint into the mouth of the test tube. Observe the lighted splint.
3. Add 3 mL of diluted HCl solution into a test tube. Drop two pieces of mossy zinc into the solution. Observe.
4. Add 3 mL of concentrated HCl solution into a test tube. Drop two pieces of mossy zinc into the solution. Observe and compare the result with the previous step.
5. Add 3 mL of $CuSO_4$ solution to a pinch of iron filings in a test tube. Observe the mixture after five minutes.
6. Mix 2 mL of $AgNO_3$ solution and an inch of copper turning. Observe.
7. Add 1 mL of $BaCl_2$ solution to 3 mL of H_2SO_4 solution in a test tube. Observe the change in temperature of the solution.
8. Add 1 mL of $AgNO_3$ to 3 mL of $BaCl_2$solution in a test tube. Observe.
9. Add 1 mL of H_2SO_4 to 3 mL of NaOH solution. Observe the change in temperature.

V. SET-UP

Draw the set-up used in the experiment.

VI. RESULTS

CHEMICALS	OBSERVATIONS	CHEMICAL EQUATION	TYPE OF CHEMICAL REACTION
1. Magnesium ribbon			
2. $CaCO_3$			
3. Diluted HCl and mossy zinc			
4. Conc. HCl and mossy zinc			
5. Solution of $CuSO_4$and iron filings			
6. Solution of $AgNO_3$ and copper turnings			
7. Solutions of $BaCl_2$ and H_2SO_4			
8. Solutions of $BaCl_2$and $AgNO_3$			
9. Solutions of H_2SO_4 and NaOH			

VII. GUIDE

What were the indications in each set up that show chemical reactions had occurred?

VIII. CONCLUSION

APPENDIX G

EVALUATION TOOL FOR THE VALIDATION OF THE CHEMISTRY LABORATORY ACTIVITIES

Personal Profile Form

Direction: Please fill in the necessary information asked in the questionnaire by supplying data or by checking the item in the space provided for each item.

Name:		Gender:	M
Present Position/ Rank:	Asst. Prof 5	Years of Teaching Experience:	10
School/ University:	De La Salle Health Science Institute	Subjects Taught:	Gen Chem, Org Chem, Biochem, PhyChem etc.

Highest Educational Attainment:

	Doctorate Degree
/	Master's Degree with PhD Units
	Master's Degree
	Bachelor's Degree with MA units
	Bachelor's Degree

Specialization: Chemistry (Natural Products Chemistry)

- -

Direction: Please put a check (✓) mark on your assessment on the level of acceptability of the chemistry laboratory activities based on the following set criteria. These laboratory activities will be used by Grade 10 students.

Please assess using the following scales with corresponding interpretation and descriptions

Scale	***Interpretation***	***Description***
5	Very Acceptable	*The statement is highly evident in the developed chemistry laboratory activities*
4	Acceptable	*The statement is evident in the developed chemistry laboratory activities*
3	Moderately Acceptable	*The statement is somehow evident in the developed chemistry laboratory activities*
2	Least Acceptable	*The statement is not that evident in the developed chemistry laboratory activities*
1	Not Acceptable	*The statement is really not evident in the developed chemistry laboratory activities*

The **CONTENT** of the developed chemistry laboratory activities:	**5**	**4**	**3**	**2**	**1**
1. *are briefly and clearly stated*				□	
2. *are aligned to the set learning competencies*		□			
3. *contains specific laboratory objectives and well-organized procedure that leads student in making proper conclusion.*	□				
4. *provides adequate means of presenting results and discussion of the activities like table forms.*		□			
5. *are designed to help students to develop better conceptual understanding of science concepts (chemistry).*		□			
6. *provides means of addressing students' difficulties and misconceptions of science concepts (chemistry).*		□			
7. *helps students to demonstrate and to enhance their science laboratory skills.*	□				
8. *contains safety precautionary measures.*	□				

The **LANGUAGE** used in the developed chemistry laboratory activities:	**5**	**4**	**3**	**2**	**1**
1. *is easy to understand*		□			
2. *avoids too much technical terms*		□			
3. *is free of misspelled words*			□		
4. *is free from grammatical errors*		□			
5. *provides instructions that are easy to follow and procedures in correct sequence*		□			

The **LAYOUT** of the developed chemistry laboratory activities:	**5**	**4**	**3**	**2**	**1**
1. *shows readability of text*	□				
2. *has distinct parts or segments*	□				
3. *contains clear instruction and appealing layout*		□			
4. *has tables designed to present necessary data or results of the laboratory activities*	□				
5. *provides enough and appropriate space for the students to draw their conclusion.*	□				

Comments / Suggestions for the improvement of the Chemistry Laboratory Activities:

____
Rater's Signature over Printed Name

APPENDIX H

Students' Attitude Towards Chemistry Laboratory

Domains	5		4		3		2		1		Mean	SD	Rank	Remark
	f	%	f	%	f	%	f	%	f	%				
Interest	300	68.81	101	23.17	35	8.03	0	0	0	0	4.61	0.63	1	Strongly Agree
Enjoyment	501	65.66	211	27.65	51	6.68	0	0	0	0	4.59	0.61	2	Strongly Agree
Practicality	343	52.45	167	25.54	144	22.02	0	0	0	0	4.30	0.81	4	Agree
Way of Learning	310	47.40	203	31.04	135	21	6	0.92	0	0	4.25	0.81	5	Agree
Value	135	61.93	61	27.98	16	7.34	6	2.75	0	0	4.49	0.75	3	Agree
OVERALL	1589	59.25	743	27.08	381	12.94	12	0.73	0	0.00				

N = 109

APPENDIX I

Students' Perceived Laboratory Environment

Domains	5		4		3		2		1		Mean	SD	Rank	Remark
	f	%	f	%	f	%	f	%	f	%				
Student Cohesiveness	468	61.34	190	24.90	105	13.76	0	0	0	0	4.48	0.72	3	Agree
Open-endedness	156	20.45	155	20.31	438	57.40	7	0.92	7	0.92	3.58	0.85	5	Agree
Integration	187	24.51	241	31.59	335	43.91	0	0	0	0	3.80	0.80	4	Agree
Rule Clarity	495	64.88	177	23.20	91	12	0	0	0	0	4.53	0.70	1	Strongly Agree
Material Environment	496	65.01	186	24.38	66	8.65	0	0	15	1.97	4.50	0.81	2	Strongly Agree
OVERALL	1802	47.23	949	24.88	1035	27.13	7	0.18	22	0.58				

N = 109

APPENDIX J

Students' Laboratory Performance Skills

Component	4		3		2		1		Mean	SD	Rank	Remark
	f	%	f	%	f	%	f	%				
Experimental procedures	37	33.94	53	48.62	19	17.43	0	0.00	3.17	0.70	8	Often
Physical preparation	102	93.58	7	6.42	0	0.00	0	0.00	3.94	0.25	1	Always
Laboratory techniques	0	0.00	80	73.39	21	19.27	8	7.34	2.66	0.61	11	Often
Collaboration and leadership	26	23.85	53	48.62	22	20.18	8	7.34	2.89	0.85	9	Often
Task management	55	50.46	33	30.28	21	19.27	0	0.00	3.31	0.78	6	Often
Safety procedures	95	87.16	14	12.84	0	0.00	0	0.00	3.87	0.34	3	Always
Oral communication	47	43.12	62	56.88	0	0.00	0	0.00	3.43	0.50	5	Often
Organization and set-up	38	34.86	61	55.96	10	9.17	0	0.00	3.26	0.61	7	Often
High quality results	74	67.89	35	32.11	0	0.00	0	0.00	2.68	0.47	10	Often
Time management	66	60.55	28	25.69	15	13.76	0	0.00	3.47	0.73	4	Often
Housekeeping	97	88.99	12	11.01	0	0.00	0	0.00	3.89	0.31	2	Always
OVERALL	220	40.37	226	41.47	83	15.23	16	2.94	3.32	0.56		

N = 109

APPENDIX K

Difference in Student's Laboratory Performance Skills by Attitude towards Chemistry Laboratory

Domain	Level	Freq	%	Min	Max	M	SD	CV	DF	F	Fcrit	p-level	Remark
Interest	5	81	74.31	2.455	3.636	3.297	0.352	0.107	1, 107	4.210	3.930	0.043	significant
	4	28	25.69	2.727	3.636	3.399	0.241	0.071					
Enjoyment	5	66	60.55	2.455	3.636	3.357	0.314	0.093	1, 107	3.966	3.930	0.049	significant
	4	43	39.45	2.455	3.636	3.273	0.347	0.106					
Practicality	5	54	49.54	2.455	3.636	3.290	0.384	0.117	2, 106	4.100	3.080	0.019	significant
	4	46	42.20	2.545	3.636	3.358	0.246	0.073					
	3	9	8.26	2.545	3.636	3.354	0.330	0.099					
Way of Learning	5	43	39.45	2.455	3.636	3.285	0.366	0.111	2, 106	4.612	3.080	0.012	significant
	4	59	54.13	2.455	3.636	3.336	0.310	0.093					
	3	7	6.42	3.182	3.636	3.455	0.182	0.053					
Value	5	79	72.48	2.455	3.636	3.312	0.342	0.103	2, 106	3.227	3.080	0.044	significant
	4	24	22.02	2.545	3.636	3.337	0.308	0.092					
	3	6	5.50	3.182	3.636	3.424	0.214	0.063					
Composite	5	46	42.20	2.455	3.636	3.298	0.379	0.115	2, 106	4.590	3.930	0.012	significant
	4	57	52.29	2.455	3.636	3.342	0.287	0.086					
	3	6	5.505	2.455	3.636	3.121	0.447	0.143					

$p < .05$

APPENDIX L

Difference in Student's Laboratory Performance Skills by Perceived Laboratory Environment

Domain	level	f	%	min	max	mean	sd	cv	df	f value	fcrit	p-level	remarks
Student Cohesiveness	5	61	55.96	2.455	3.636	3.404	0.260	0.076	1, 107	8.715	3.93	0.004	significant
	4	48	44.04	2.455	3.636	3.222	0.378	0.117					
Open-endedness	4	54	49.54	2.455	3.636	3.342	0.298	0.089	1, 107	0.32	3.93	0.573	not significant
	3	55	50.46	2.455	3.636	3.306	0.341	0.103					
Integration	5	16	14.68	3.091	3.636	3.466	0.187	0.054	2, 106	2.604	3.08	0.079	not significant
	4	64	58.72	2.455	3.636	3.270	0.364	0.111					
	3	29	26.61	2.455	3.636	3.364	0.278	0.083					
Rule Clarity	5	63	57.80	2.455	3.636	3.364	0.306	0.091	2, 106	3.941	3.08	0.022	significant
	4	43	39.45	2.455	3.636	3.290	0.357	0.109					
	3	4	3.67	2.727	3.182	3.045	0.187	0.061					
Material Environment	5	55	50.46	2.455	3.636	3.347	0.296	0.088	1, 107	4.600	3.93	0.034	significant
	4	54	49.54	2.455	3.636	3.300	0.360	0.109					
Composite	5	7	6.42	3.545	3.636	3.377	0.203	0.060	2, 106	3.954	3.08	0.022	significant
	4	100	91.74	2.455	3.636	3.314	0.337	0.102					
	3	2	1.835	3.182	3.636	3.49	0.227	0.065					

$p<.05$

APPENDIX M

Correlation between Student's Laboratory Performance Skills and Attitude towards Chemistry Laboratory (r and r^2)

Laboratory Performance Skills Component	Interest	Enjoyment	Practicality	Way of Learning	Value	Attitude towards Chemistry Laboratory Composite
Experimental procedures	0.058	0.145	0.195	0.090	0.128	0.216
	0.003	0.021	0.038	0.008	0.016	0.047
Physical preparation	0.103	0.233	0.129	0.040	0.217	0.068
	0.011	0.054	0.017	0.002	0.047	0.005
Laboratory techniques	0.019	0.060	0.146	0.276	0.199	0.101
	0.000	0.004	0.021	0.076	0.040	0.010
Collaboration and leadership	0.098	0.107	0.021	0.166	0.070	0.021
	0.010	0.011	0.000	0.028	0.005	0.000
Task management	0.137	0.016	0.299	0.305	0.114	0.230
	0.019	0.000	0.089	0.093	0.013	0.053
Safety procedures	0.103	0.334	0.129	0.249	0.217	0.377
	0.011	0.112	0.017	0.062	0.047	0.142
Oral communication	0.020	0.109	0.461	0.046	0.042	0.299
	0.000	0.012	0.213	0.002	0.002	0.089
Organization and set-up	0.288	0.057	0.860	0.307	0.150	0.205
	0.083	0.003	0.740	0.094	0.023	0.042
High quality results	0.107	0.020	0.150	0.161	0.040	0.025
	0.011	0.000	0.023	0.026	0.002	0.001
Time management	0.055	0.192	0.259	0.008	0.116	0.174
	0.003	0.037	0.067	0.000	0.013	0.030
Housekeeping	0.170	0.075	0.103	0.098	0.051	0.075
	0.029	0.006	0.011	0.010	0.003	0.006
Laboratory Performance Skills Composite	0.065	0.038	0.239	0.211	0.059	0.206
	0.004	0.001	0.057	0.045	0.003	0.424

significant at $p<.05$

APPENDIX N

Correlation between Student's Laboratory Performance Skills andPerceived Laboratory Environment (r and r^2)

Laboratory Performance Skills Component	Student Cohesiveness	Open-endedness	Integration	Rule Clarity	Material Environment	Perceived Laboratory Composite
Experimental procedures	0.358	-0.071	0.240	0.592	0.206	0.489
	0.128	0.005	0.058	0.350	0.042	0.239
Physical preparation	0.204	0.335	-0.129	0.194	0.296	0.351
	0.042	0.112	0.017	0.038	0.088	0.123
Laboratory techniques	0.189	0.326	0.113	0.428	0.087	0.241
	0.036	0.106	0.013	0.183	0.008	0.058
Collaboration and leadership	0.015	0.400	0.068	0.431	0.134	0.118
	0.000	0.160	0.005	0.186	0.018	0.014
Task management	0.225	0.023	0.242	0.506	0.018	0.220
	0.051	0.001	0.059	0.256	0.000	0.048
Safety procedures	0.297	0.234	0.297	0.109	0.407	0.272
	0.088	0.055	0.088	0.012	0.166	0.074
Oral communication	0.160	0.078	0.054	0.021	-0.152	0.137
	0.026	0.006	0.003	0.000	0.023	0.019
Organization and set-up	0.469	0.310	-0.037	0.298	0.073	0.467
	0.220	0.096	0.001	0.089	0.005	0.218
High quality results	0.275	0.056	-0.070	0.200	0.020	0.191
	0.076	0.003	0.005	0.040	0.000	0.036
Time management	0.367	0.201	0.027	0.083	-0.126	0.083
	0.135	0.040	0.001	0.007	0.016	0.007
Housekeeping	0.436	0.139	0.423	0.222	0.219	0.221
	0.190	0.019	0.179	0.049	0.048	0.049
Laboratory Performance Skills Composite	0.414	0.085	0.101	0.538	0.115	0.385
	0.171	0.007	0.010	0.289	0.013	0.148

significant at p<.05

APPENDIX O

Standardized Regression Coefficient (β): Laboratory Performance Skills by Attitude towards Chemistry Laboratory

Laboratory Performance Skills Component	Interest	Enjoyment	Practicality	Way of Learning	Value	Attitude towards Chemistry Laboratory Composite
Experimental procedures	0.058	0.145	0.195	0.090	0.128	0.216
Physical preparation	0.103	0.233	0.129	0.040	0.217	0.068
Laboratory techniques	0.019	0.060	0.146	0.276	0.199	0.101
Collaboration and leadership	0.098	0.107	0.021	0.166	0.070	0.021
Task management	0.137	0.016	0.299	0.305	0.114	0.230
Safety procedures	0.103	0.334	0.129	0.249	0.217	0.377
Oral communication	0.020	0.109	0.461	0.046	0.042	0.299
Organization and set-up	0.288	0.057	0.086	0.307	0.150	0.205
High quality results	0.107	0.020	0.156	0.161	0.040	0.250
Time management	0.055	0.192	0.259	0.008	0.116	0.174
Housekeeping	0.170	0.075	0.103	0.098	0.051	0.075
Laboratory Performance Skills Composite	0.065	0.038	0.239	0.211	0.059	0.208

significant at $p<.05$

APPENDIX P

Standardized Regression Coefficient (β): Laboratory Performance Skills by Perceived Laboratory Environment

Laboratory Performance Skills Component	Student Cohesiveness	Open-endedness	Integration	Rule Clarity	Material Environment	Perceived Laboratory Composite
Experimental procedures	0.358	-0.071	0.240	0.592	0.206	0.489
Physical preparation	0.204	0.335	-0.129	0.194	0.296	0.351
Laboratory techniques	0.189	0.326	0.113	0.428	0.087	0.241
Collaboration and leadership	0.015	0.400	0.068	0.431	0.134	0.118
Task management	0.225	0.023	0.242	0.506	0.018	0.220
Safety procedures	0.297	0.234	0.297	0.109	0.407	0.272
Oral communication	0.160	0.078	0.054	0.021	-0.152	0.137
Organization and set-up	0.469	0.310	-0.037	0.298	0.073	0.467
High quality results	0.275	0.056	-0.070	0.200	0.020	0.191
Time management	0.367	0.201	0.027	0.083	-0.126	0.083
Housekeeping	0.436	0.139	0.423	0.222	0.219	0.221
Laboratory Performance Skills Composite	0.414	0.085	0.101	0.538	0.115	0.385

significant at $p<.05$

APPENDIX Q

Standardized Regression Coefficient (β): Laboratory Performance Skills by Perceived Laboratory Environment and Attitude towards Chemistry Laboratory

Laboratory Performance Skills Component	Perception	Attitude
Experimental procedures	0.487	0.221
Physical preparation	0.351	0.064
Laboratory techniques	0.242	0.103
Collaboration and leadership	0.117	0.020
Task management	0.220	0.232
Safety procedures	0.268	0.374
Oral communication	0.140	0.300
Organization and set-up	0.469	0.210
High quality results	0.192	0.247
Time management	0.085	0.175
Housekeeping	0.220	0.073
Laboratory Performance Skills Composite	0.386	0.206

significant at p<.05

APPENDIX R

Communication Letters

Dear Parent/Guardian,

I am currently enrolled in the M.A. Science Education with Specialization in Chemistry at Philippine Normal University and in the process of writing my Master's Thesis. My study dwells in evaluating the students' skills and behavior as they conduct experiment during Chemistry laboratory classes. Furthermore, it aims to determine how students view an ideal laboratory

I am writing to ask if you would be willing to give permission for me to ask your daughter if she would like to take part in my study. This will involve taking part in a survey and interviewing your daughter in order to find out what she finds helpful in a chemistry laboratory experiment and her attitudes towards chemistry experiment. This study will be supervised by her teacher in chemistry. The survey and interview would take place at St. Scholastica's Academy Marikina during their chemistry class. It will take between 15 minutes and, at most, 20 minutes of your daughter's time. Please note that your child's participation is completely voluntary. She will not be affected in any way by participation in this evaluation study. Your child will be told about this study and will be asked to sign an assent form stating whether she wants to participate.

Any information that is obtained in connection with this study and can be identified with your child will remain confidential. Her name will not appear in any public document, including articles or reports on the project. Her responses will not be linked her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study and your child will receive no direct benefit from participating in the study. Neither your child nor you will receive any type of payment for participating in this study. I will be happy to share materials from this program with you at any time. If you have any comments or questions about this research, you may contact the researcher through the information given below.

Hoping for your favorable response.
Sincerely,

Mr. Amor C. Mallari
SSAM HS Science Coordinator
09205422990
mr_amor_mallari@yahoo.com

****

PARENT'S CONSENT

I have read this letter which asks me to allow my daughter be part of a study at her school. I have understood the information about the study and I know what my daughter will be asked to do. I am allowing/not allowing (kindly underline your response) her to be in the study.

Name and Signature of Parent/guardian: ……………………………………………………..

Date: ……………………………………………………..

Name of Child: ……………………………………………………..

Dear Student,

I am interested in knowing your views and actions when you conduct experiment during Chemistry laboratory classes. I am also interested to know how what will be your description of and describe an ideal laboratory environment.

In line with this, I would like to invite you to be part of my study. This letter is to explain to you what I would like you to do. There may be some words you do not know in this letter. You may ask me or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

We will conduct a chemistry experiment during our chemistry class. Before and after the experiment, you will answer questionnaires pertaining to your preferences and attitudes when we are doing the chemistry experiments. During the experiment, two other chemistry teachers will help me to do my task. I will mark your questionnaire sheet afterwards. Do not worry because your name will not appear on the paper and it will not count for any marks at school. I will not share your test results with the teachers. You will spend about fifteen (15) minutes answering the questionnaires.

Should you decide to participate, simply fill-up the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another adult contact me at 09205422990. You can also call our high school office at 9410231 and look for me.

Hoping that you will be part of this endeavor.

Sincerely,
Mr. Amor C. Mallari
SSAM HS Science Coordinator
09205422990

****

WRITTEN ASSENT

I have read this letter which asks me to be part of a study at my school. I have understood the information about the study and I know what I will be asked to do. I am willing/not willing (kindly underline your response) to be in the study.

Learner's Name and Signature: ……………………………………………………..

Date: ……………………………………………………..

Directress
St. Scholastica's Academy Marikina

Dear:

I am currently enrolled in the M.A. Science Education with Specialization in Chemistry at Philippine Normal University and in the process of writing my Master's Thesis. My study dwells in evaluating the students' skills and behavior as they conduct experiment during Chemistry laboratory classes. Furthermore, it aims to determine how students view an ideal laboratory environment.

In line with this, I am writing to request your permission to allow the conduct my study in your institution. I hope that the school administration will allow me to recruit three sections of Grade 10 students and complete a 6-page questionnaire (copy enclosed). Interested students, who volunteer to participate, will be given a consent form to be signed by their parent or guardian (copy enclosed), upon which they will return to me at the beginning of the survey process.

Should you given approval, student participants will complete the survey in a classroom during their chemistry laboratory period. The survey process should take no longer than 20 minutes. The survey results will be pooled for the thesis project and individual results of this study will remain absolutely confidential and anonymous. Should this study be published, only pooled results will be documented. No costs will be incurred by either your school or the individual participants.

As to results, it will be of utmost confidentiality. Hoping for the favorable response.

Sincerely,
Mr. Amor C. Mallari
SSAM HS Science Coordinator

Chemistry Teacher
St. Scholastica's Academy Marikina

Dear:

I am currently enrolled in the M.A. Science Education with Specialization in Chemistry at Philippine Normal University and in the process of writing my Master's Thesis. My study dwells in evaluating the students' skills and behavior as they conduct experiment during Chemistry laboratory classes. Furthermore, it aims to determine how students view an ideal laboratory environment.

In line with this, I would like to invite you to be part of my study as an observer. Should you be willing, allow me to request the following:

1. Observe my classes during laboratory period
2. Evaluate students' skill using the Laboratory Performance Observation Assessment Tool (document is attached)
3. Participate in the interview/discussion.

If you have any queries or concerns, or additional information before taking part in my study, I am more than willing to answer these.

Hoping for your favorable response.

Sincerely,
Mr. Amor C. Mallari
SSAM HS Science Coordinator
09152991214

Evaluator
Address

Dear:

I am currently enrolled in the M.A. Science Education with Specialization in Chemistry at Philippine Normal University and in the process of writing my Master's Thesis. My study dwells in evaluating the students' skills and behavior as they conduct experiment during Chemistry laboratory classes. Furthermore, it aims to determine how students view an ideal laboratory environment.

With your expertise, I am humbly requesting your permission to validate the following questionnaires and rubric for my study:

1. Laboratory Performance Observation Assessment Tool (LPOAT)
2. Science Laboratory Environment Inventory Questionnaire (SLEIQ)
3. Attitude Towards Chemistry Laboratory Work Questionnaire (ATCLWQ)

Attached are the rating tools for this task.

Hoping for your favorable response.

Thank you and God bless!

Sincerely,
Mr. Amor C. Mallari
Researcher
09152991214

NOTED BY:

Prof. Nelson Garcia	Prof. Brando Palomar
Adviser	Adviser

APPENDIX S

TurnitinOriginality Report

Philippine Normal University
College of Graduate Studies and Teacher Education Research
PUBLICATION OFFICE

AUTHENTICITY RESULT

ate of Release:	March 4, 2016
esult Code:	2016-096
ubmission ID:	641096718
tle of Output:	Students' Perceived Environment, Attitudes, and Skills in Chemistry Laboratory
uthor(s):	Amor Mallari

Authenticity Report:

- ***Similarity Report: 10%***
- ***Interpretation***: A similarity report of 10% means that 10% of the whole paper is similar to sources in Turnitin's (authenticity software) online repository. The colored bibliographical references denote the sources of similarity to previously published work which maybe from internet sources (7%), publications (6%) and student papers (4%) for the remaining similarity percentage.
- ***Highlighted text in the Manuscript***:
    - Red marks and highlights are set of texts directly or exactly copied from online sources
    - Other color marks and highlights are set of text exactly copied from other sources (student papers and publications).

Rio Anne R. Maño
(Authenticity Administrator)

Noted by:

Dr. Marie Paz E. Morales
Director, Publications Office

APPENDIX T

Academic Language Editing Result

March 17, 2016

Academic Language Editing Certificate

I had reviewed the thesis entitled: "Students' Perceived Environment, Attitudes, and Performance Skill in Chemistry Laboratory"; written by: Mr. Amor Mallari.

I hereby certify that thus thesis met the criterion following the academic language.

Mrs. Menere R. Nasiad
Language Consultant

CURRICULUM VITAE

PERSONAL DATA:

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Marital Status: Single
Date of Birth: 20/June/1987
Gender: Male
Nationality: Filipino
Languages and Fluency Level: Filipino and English

EDUCATION:

BS Chemistry for Teachers, *Philippine Normal University, Taft Avenue, Manila,* **06/2004 to 03/2008**.

WORK HISTORY:

Faculty, *St. Scholastica's Academy, Marikina, Marikina Height, Marikina City,* **05/2011 to present.**

- HS Department Science Coordinator, chemistry teacher, class adviser, and club moderator.

Faculty, *St. Mary's College Quezon City, Mo. Ignacia Street, Quezon City,* **05/2008 to 04/2011.**

- Science teacher, class adviser, and club moderator.

LICENSURE AND PROFESSIONAL AFFILIATION:

Licensure Examination for Teachers, *Passer*, **10/2008**

Association of Science Educators in the Philippines, *Member,* **2011 to present**