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Towards Developing a Proposed Model of Teaching-Learning Process Based on the Best Practices in Chemistry Laboratory Instruction

Paz B. Reyes
Lyceum of the Philippines University, Batangas City, Philippines

Rebecca C. Nueva España
College of Graduate Studies and Teacher Education Research, Philippine Normal University, Manila, Philippines

Rene R. Belecina
College of Graduate Studies and Teacher Education Research, Philippine Normal University, Manila, Philippines

Abstract. This study investigated the teaching practices employed by the faculty of the Lyceum University System in teaching chemistry laboratory in order to attain the seven goals of laboratory instruction: (2) mastery of subject matter; (b) scientific reasoning; (c) understanding complexity and ambiguity of empirical work; (d) practical skills; (e) understanding the nature of science; (f) interest in science and in learning science; and (g) teamwork skills. It also determined the extent by which the attainment of the goals of science laboratory instruction was manifested in the students' (a) attitude and motivation; (b) laboratory skills; and (c) achievement. Finally, a proposed model of teaching-learning process in chemistry laboratory instruction was developed based on the identified best teaching practices. The qualitative-quantitative methods of research particularly the descriptive design were used. To gather data, interview was conducted to separate groups of students and faculty. Further, classroom observations and questionnaires were conducted and administered to gather other pertinent data. The subjects of the study were eighty students enrolled in General Chemistry during the second semester of the school year 2011-2012 and 4 chemistry instructors. The chemistry instructors were chosen from each of the four universities included in the Lyceum University System. With the aim of determining the best teaching practices employed by the faculty in teaching chemistry laboratory, five instruments were developed and validated by experts: Focus Group Interview Questionnaire for faculty and for Students; Observation Checklist; Attitude/Motivation Instrument; Practical Test; and the Achievement Test. The data analysis made use of frequency, percentage, mean and standard deviation. The results of the study revealed that the teaching practices of the chemistry faculty of the Lyceum University System were based on the university vision, mission goals and objectives and therefore attained the seven goals of the science laboratory instruction. Likewise, the students acquired a positive attitude towards chemistry, high competency in laboratory skills and average level of achievement in the subject. It can be deduced from the findings that indeed the best practices of the faculty in teaching chemistry laboratory are those practices where students engaged in experiential learning, active learning, meaningful learning, and cooperative learning. It was manifested in the students' attitude/motivation, laboratory skills and achievement as shown by their interest in chemistry and in learning chemistry, their cognitive and manipulative skills and their understanding of the concept. The use of the proposed model of constructivist teaching-learning process is recommended for an effective chemistry laboratory instruction.

Keywords: best practices in chemistry laboratory instruction, teaching-learning model in chemistry

Introduction

Science and technology play a major role in man's quest for quality of life which subsequently causes a great impact to society. Science is relatively an experimental field, and most of the time learning its concepts and skills happen in the laboratory. Investigating scientific phenomena and testing hypotheses begin with making observations and gaining reasons for or describing observed situations. As such, it is the supreme art of the science teacher to awaken a child's curiosity and enkindle the eagerness to explore, to search for knowledge, truth and harmony.

To Petrucci, Herring, Madura & Bissonnette (2002), inculcating scientific discipline among learners reflect a response to a higher goal of learning. With different governments in the world trying to redefine and fine tune education, it is therefore imperative to develop more capacity building in science and technology. In the Philippines, for instance the 1986 Constitution provides support for science and technology. Article XIV reads: *"Science and Technology are essential for national development and progress. The state shall give priority to research and development, invention, innovation and their utilization; and to science and technology education, training and services. It shall support indigeneous, appropriate, and self – reliant scientific and technological capabilities, and their application to the country's productive system and national life."*

Among the different scientific discipline, Chemistry is regarded as an active and continually growing science and is focussed on realms of both nature and society. Chang (2009) posited that "Chemistry is every bit a modern science, an experimental science that rests on a foundation of precise vocabulary and established methods." Following this line of thinking, chemistry must be concerned not only with the teaching of concepts, but also of laboratory skills. Therefore, to study chemistry is to understand how concepts are translated into application in a laboratory setting.

Among the scientific changes in the concept of chemistry teaching in the last decade is the emphasis of laboratory work as an efficient and meaningful technique in learning science concepts. This change is patterned on Salandanan's (2002) definition of experiment which is a mean of illustrating the basic concepts of science and giving a clear view of the topics studied in class. Wink, Gislason, & Kuehn (2000) further validated that through experimentation, knowledge can be formed and in some instances erroneous beliefs that have been passed down by authority can be discarded.

Still, chemistry is not complete without laboratory works because it is where students can discover things for themselves, where they can be actively involved in identifying and using varied chemicals

With the onset of modern learning styles and modes of education, it is imperative to consider the different learning tasks in teaching college chemistry to make the system more responsive to the demands of the 21st century. In fact, at the collegiate level, all students should have opportunities to experience more meaningful science laboratory investigations. Such laboratory experiences should aim to address how students should be taught how to work independently and collaboratively as well as incorporate and critique scientific studies published. Moreover, laboratory experiences must teach students how to develop scientific reasoning and appropriate laboratory techniques to define and solve problems, and finally, to draw and evaluate conclusions based on quantitative evidences. Laboratories should correlate closely with lectures and should not be separate activities. This fact reflects that exposure to rigorous, inquiry – based laboratories at the college level duplicates the same experience the science teachers had when they took their undergraduate studies.

On the part of the educators, it is not enough for chemistry teachers to simply give facts, figures, concepts, theories, laws and other data, but they should be concerned with incorporating new teaching methods into their laboratory activities and development of courses with more realistic expectations of student involvement in experimental designs, data analyses and data interpretations. Linking laboratory activities which the students really enjoy provides a wider span of meaningful learning and development for both teachers and students (National Science Teachers Association, 2007). To achieve such meaningful learning, laboratory instruction must be designed in a way that it will develop not only the cognitive but also the manipulative skills of students. Again, the argument remains the same, it is not enough for students to learn the concept, it must be taught together with the process.

As active participants in science laboratories, students gain a deeper sense of understanding and a greater confidence in their learning. With the acknowledged importance of a laboratory experience for all students, it is necessary for instructors to think clearly about the elements that could help achieve an effective laboratory experience. For instance, it is of great importance to know what techniques can be utilized to encourage students to confidently contribute to their laboratory groups.

Corollary to this, which scientific skills and procedures must be practiced and mastered by students to achieve that level of confidence during laboratory works. Still another important point to emphasize are the kinds of instruments in a science laboratory which students should be familiar with. Similarly, understanding the importance of the "other laboratory skills" such as communication (written and oral), teamwork, ethics, fairness, and responsibility should be taught to maximize students' participation in performing experiments.

In a study conducted by Narayan (2005), she suggested that for students to be engaged in science, they needed to be involved in "learning to use language, think and act in ways that enable one to be identified as a member of the scientific literate community and participate in the activities of that community". She added that learning occurs more effectively when the student is socialized into a community of practice that he is immersed in.

Most science educators encourage fellow teachers to provide students with access to more authentic science activities. Queries on possible steps to take on how to improve the delivery of science lessons and skills remains to be the primary objective in redevelopment and restructuring of pedagogical practices in science classrooms

The Lyceum of the Philippines University, one of the country's premier institutions, set the standards of commitment in pursuing excellence in education. Guided by its vision, mission and core values, the university offers various science programs which include laboratories as an integral part of the curriculum.

The researcher, as a science educator, is concerned with the meaningful learning of students in chemistry. With her several years of teaching chemistry laboratory, the issue on what strategies to use to help students develop positive attitude towards chemistry and become independent learners who are ready to face the challenges of the 21st century science education, has been her problem. Thus, the researcher attempted to investigate the best teaching practices that will focus on the attainment of the goals of chemistry laboratory instruction which aims to develop positive attitude and high motivation of students as well as competency on their laboratory skills which could lead to high probability of achievement.

Conceptual Framework

This study is anchored on Piaget's Theory of Constructivism which encourages learning through collaboration and interchange among the students themselves. Piaget (Muijs and Reynolds, 2011) suggested that students construct new knowledge from their experiences through "accomodation and assimilation." Constructivism as a learning theory views learning as a process in which "students actively construct or build new ideas and concepts based upon prior knowledge and new information." Further, it suggests that instruction should follow some basic principles such as; (1) children should be allowed to make mistakes and correct these on their own thereby enabling them to accommodate, assimilate and reconstruct knowledge on their own; discovery learning is emphasized; (2) the process of experimentation at all stages is important; and (3) knowledge is always a construction by the learner which involves operative processes that lead to transformation of reality, either in action or thought therefore experimentation should be done continually. The constructivist teacher encourages students to discover principles and construct knowledge within a given framework or structure by helping students connect with prior knowledge and experiences while new information is being presented. Through constructivism students can dispense their misconceptions and build a correct understanding.

Constructivism is a conceptual basis of this study because practices in chemistry laboratory instruction if tailored on the elements of constructivism will lead to the attainment of the seven goals of science laboratory instruction and will develop positive attitude, competency in laboratory skills and high achievement of students

In Shulman's view as cited by Rowan, Schilling, Ball & Miller (2011), the trend in education is one that addresses the pedagogical content knowledge (PCK). PCK is a form of practical knowledge that entails, among other things: (a) knowledge of how to structure and represent academic content for direct teaching to students; (b) knowledge of the common conceptions, misconceptions, and difficulties that students encounter when learning particular content; and (c) knowledge of the specific teaching strategies that can be used to address students' learning needs in particular classroom circumstances. PCK is concerned with the representation and formulation of concepts, pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior knowledge and theories of epistemology. It further views the knowledge of what the students bring to the learning situation, knowledge that might be either facilitative or dysfunctional for a particular learning task at hand. This knowledge of students includes their strategies, prior conceptions (both "naïve" and instructionally produced); misconceptions students are likely to have about a particular domain and potential misapplications of prior knowledge. PCK represents the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organized, adapted, and represented for instruction. Finally, Rowan, et al. (2011) argued that "pedagogical content knowledge" reflects the content knowledge that deals with the teaching process, including "the ways of representing and formulating the subject that make it comprehensible to others." In a larger vantage and scope, therefore, a constructivist chemistry teacher implement the best teaching practices in chemistry laboratory if he/she has a knowledge of both content and pedagogy. This idea makes not only constructivism but also pedagogical content knowledge as the conceptual bases of this study.

Studies have revealed that there are seven goals of laboratory instruction in Science Education (Singer, Hilton, & Schweingruber, 2005 and Jona, Adsit & Powell, 2008). These goals include a) enhancing mastery of subject matter b) developing scientific reasoning c) understanding the complexity and ambiguity of empirical work d) developing practical skills e) understanding the nature of science f) cultivating interest in science and interest in learning science and g) developing teamwork skills. These goals were achieved in the classroom, according to Jona, et al. (2008) if a student shows mastery of subject matter by readily remembering and understanding the concepts taught. On the same level, if a student manifests the ability to apply the knowledge acquired, then the student has mastery of subject matter. Scientific reasoning is manifested in the students' ability to explain, predict and control the occurrence of events. Students understand the complexity and ambiguity of empirical work if they can address the challenges inherent in directly observing and manipulating the material world. Practical skills are developed if students can use scientific equipment correctly and safely, make observations, take measurements and carry out well-defined scientific procedures. The nature of science is being understood if students can interpret data from the material world and they can discover that different people may interpret the same data differently. Interest in science and interest in learning science may be reflected from the positive attitude and high motivation of students. Teamwork skills are developed if students have the ability to collaborate effectively with others. To achieve all these goals, therefore, teachers must implement practices to address positive attitude, high motivation, competency in laboratory skills and high achievement in the subject.

Figure 1 shows the conceptual paradigm of the study. The study focused on the investigation of the best practices in teaching chemistry laboratory with the purpose of attaining the seven goals of laboratory instruction in science education.

Chemistry Laboratory Instruction must be student–centered which is focused on how students are motivated to acquire positive attitudes towards chemistry, competencies in lab skills and high achievement. To achieve this goal, teachers must integrate the seven goals of science lab instruction in their practices to address a student-centered classroom setting.

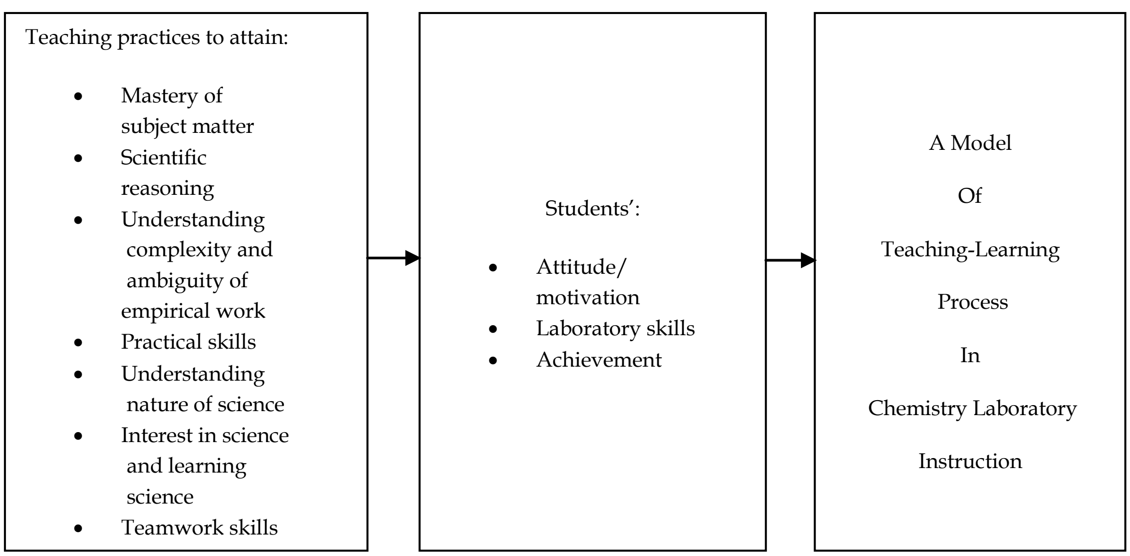


Figure 1. Conceptual Paradigm of the Best Teaching-Learning Process in Chemistry Laboratory Instruction

The first box in the paradigm reflects the teaching practices of chemistry laboratory teachers intended to attain the seven goals of science laboratory instruction. These goals include enhancing mastery of subject matter, developing scientific reasoning, understanding the complexity and ambiguity of empirical work, developing practical skills, understanding the nature of science, cultivating interest in science and interest in learning science, and developing teamwork skills. The second box on the other hand, shows the goals of science laboratory instruction are achieved by the correct pedagogical practices of the faculty. Towards the end, a model of teaching-learning process in chemistry laboratory instruction was developed from the investigated best teaching practices leading to the attainment of the seven goals which are then manifested in the attitude, motivation, laboratory skills and achievement of students.

Statement of the Problem

The main objective of the study is to propose a model of a teaching-learning process based on the identified best practices in chemistry laboratory instruction.

Specifically, the study sought answers to the following questions:

1. What are the teaching practices employed by the faculty in teaching chemistry laboratory in order to attain the seven goals of science laboratory instruction?
    - 1.1 mastery of subject matter
    - 1.2 scientific reasoning
    - 1.3 understanding of the complexity and ambiguity of empirical work
    - 1.4 practical skills
    - 1.5 understanding of the nature of science
    - 1.6 interest in science and interest in learning science
    - 1.7 teamwork skills
2. To what extent do students manifest the attainment of the goals of science laboratory instruction in some student-related parameters?
    - 2.1 attitude and motivation
    - 2.2 laboratory skills
    - 2.3 achievement
3. Based from the findings of the study, what model of teaching-learning process in chemistry laboratory instruction may be proposed to attain the goals of science laboratory instruction?

Goals of Laboratory Instruction in Science Education.

A better science program is said to be that which includes laboratories and other forms of scientific investigations. Scientific investigations must be conducted in accordance with the goals of laboratory instruction in science education. Singer, et al. (2005) reported in the America's Lab Report of the National Research Council the seven goals for scientific investigation as the desired targets of a comprehensive science program. These goals, he added should be taught in every science laboratory and these include the attainment of a) mastery of subject matter b) scientific reasoning c) the understanding of the complexity and ambiguity of empirical work d) practical skills e) the understanding of the nature of science f) interest in science and interest in learning science g) teamwork skills. Jona, et al. (2008) discussed further each of the seven goals of scientific investigation.

Mastery of subject matter. Similar to other disciplines, science aims to teach both established facts and concepts (content) and the skills used by professionals in that field (process). The National Research Council (2005) found that in typical programs, content and process are taught separately. However, modern educational theorists view them as related educational goals because according to Newmann and Wehlage as cited by Jona, et al. (2008), kinesthetic activities and other active learning experience help students in learning the content of the subject matter. Therefore, mastery of subject matter could be attained if concept and process are taught simultaneously. This goes exactly the opposite of typical laboratory experiences where students perform a process without a clear understanding of the relation of that process to content. For example, when students perform titration they do not understand completely why they are doing it or they cannot explain the results in terms of scientific concepts.

Furthermore, typical laboratories attempt to demonstrate scientific concepts by making students follow set processes in a recipe type just to confirm something that has been already taught. Inquiry activities, on the other hand, that include manipulation of ideas rather than materials and procedures enhance student understanding of facts and concepts.

Corollary to this, an integrated learning program was proposed by the National Research Council (2005). This program makes use of a constructivist approach which according to Teachnology (2007) attempts to make students observe and draw conclusions about concepts prior to receiving explicit instruction. The program consists of instructional design which will improve student mastery of subject matter. This includes the close integration of investigative activities into content, a merging of content instruction and process instruction, and reflection on the meaning of the learning activity once it is completed.

Scientific reasoning. Students should be taught the various kinds of scientific processes and valid reasoning principles and at the same time must be given the opportunity to practice these reasoning skills. To achieve this, laboratory instructions must be planned so that students can be encouraged to participate in designing the process of investigation, making them draw and support conclusions. In a direct contrast, a typical science course, students do not develop scientific reasoning skills because they were not given time for planning investigation or interpreting results. Experts take such scenario due to the focus of instruction only on learning content and laboratory experiences focuses upon following specified procedures.

With the integrated learning program, a variety of skills associated with scientific reasoning can be developed among students. According to the National Research Council (2005), these include the ability to identify questions and concepts leading to scientific investigations, design and conduct scientific investigations, develop and revise scientific explanations and models; recognize and analyze alternative explanations and models, and make and defend a scientific argument, including writing, reviewing information, using scientific language appropriately, constructing a reasoned argument, and responding to critical comments.

It is very well expected that a well designed science course should consider a core scientific process which deal with the ability of students to construct scientific arguments. In this process, students must be taught to design experiments, make predictions, interpret and explain data, recognize discrepancies between predicted and observed outcomes, design good experiments.

Instructional practice is effective only when students learned how to relate theoretical claims with evidences gathered from their laboratory investigations.

Understanding of the complexity and ambiguity of empirical work. To Singer, et al. (2005), scientific investigations should be properly designed in such a manner that students are able to expect outcomes or experimental results contradicting widely accepted scientific principle. Students must understand that even the same experiments may lead to different results if performed at different times or by different people. Similarly, students should not be confused with the misconceptions that science is a collection of clearly defined laboratory procedures whose outcome firmly support received instruction, instead students must know how to deal with these complexities and ambiguities of empirical work as one aspect of the nature of science.

Researchers believe that a well designed scientific investigation program must include opportunities for students to be involved in activities like troubleshooting of laboratory equipment, rechecking data observations and analysis, examining the parameters, assumption and study definitions in contradictory studies, and generally performing the kind of follow-up investigations done within the scientific community. Further, such program must allow students to understand measurement error and interpret and aggregate the resulting data.

One technique for an instructional designer is to allow students who are working in a team to perform activities independently, compare results and then discuss and account for discrepancies. Students must be allowed to make mistakes and correct them on their own. Experimental errors are not hindrances to learning, but they are opportunities for greater learning. So instead of working hard to remove complexities and ambiguities, laboratory instructors should include the expectation of experimental errors in their instruction.

Practical skills. Although practical skills refer to the proper use of scientific equipment and the conventions of science such as measuring, observing and other science processes, it is not enough for students to know how to use tools and follow correct procedures in scientific investigations. Rather, what is important is they know how to apply effectively the appropriate scientific processes to a new investigation so that they can make accurate observations and follow accepted procedures to ensure valid results.

Understanding the nature of science. In a typical science course, students do not realize that science is a human endeavor that seeks to understand the material world and that scientific theories, models and explanations change over time on the basis of new evidence. They simply see that science is a collection of laws and facts without really understanding how existing concepts came into being, how existing ideas are reshaped with new discoveries, how accepted theory differs from wild guess or from firm facts, and how new concepts and theories emerge through investigations.

In an integrated learning program, laboratory teachers should explicitly teach concepts in the instructional phase and aim to reinforce the understanding of the concepts through an investigative process. To achieve this, various instructional strategies, such as constructivist activities and activities that allow students to create their own scientific investigations to solve problems, must be implemented in their instruction. Students should be given metacognitive assignments which will allow them to reflect on their learning and to relate their experiences to scientific principles and procedures.

Interest in science and interest in learning science. Instruction is considered effective if it cultivates an interest in the subject and motivates students to continue learning more about the subject. This is made possible in science laboratory instruction by applying the five principles of authentic instruction. Scientific investigations and other laboratory activities are applications of authentic instruction which are consistent with the integrated learning process. The five principles of authentic instruction in science include: a) higher order thinking skills b) depth of knowledge c) connectedness to the world beyond the classroom d) substantive conversation and e) social support for student achievement. According to Fraser as cited by Jona, et al. (2008) an extensive study involving multiple countries (including the United States) indicated that positive student attitudes toward science are strongly associated with cohesiveness (the extent to which students know, help, and are supportive of one another) and integration (the extent to which laboratory activities are integrated with non-laboratory and theory classes).

Teamwork skills. To National Research Council (2005), scientific investigations promote a student's ability to collaborate effectively with others in carrying out complex tasks, to share the work of the task, to assume different roles at different times, and to contribute and respond to ideas. It is important in a learning community to have teamwork and collaboration among members. A well-designed collaborative authentic instruction can enhance student learning in contrast to a poorly designed collaborative process that undermine instruction and student achievement. Teamwork skills therefore, must be integrated as part of the instructional process by introducing investigate processes early in the course.

Still in the same argument, teamwork is a part of authentic instruction where substantive conversation requires interaction among members. There is high level of substantive conversation if 1) there is considerable interaction about the ideas of a topic (the talk is about disciplined subject matter and includes indicators of higher-order thinking such as making distinctions, applying ideas, forming generalizations, raising questions, and not just reporting experiences, facts, definitions, or procedures) 2) there is sharing of ideas which is evident in exchanges that are not completely scripted or controlled (as in a teacher-led recitation). Sharing is best illustrated when participants explain themselves or ask questions in complete sentences and when they respond directly to comments of previous speakers 3) The dialogue builds coherently on participants' ideas to promote improved collective understanding of a theme or topic.

In a true collaborative work, students share ideas about hypotheses, procedures and conclusions, directly contradicting how students in a typical laboratory experience work in group to divide limited laboratory equipment and space among a large number of students.

The Role of Laboratory Instruction in Science Education

The National Science Teachers Association (NSTA, 2007) defined school laboratory investigations as "an experience in the laboratory, classroom, or the field that provides students with opportunities to interact directly with natural phenomena or with data collected by using tools, materials, data collection techniques, and models." From these investigations, evidences are collected through observations which become the basis in generating scientific theories and scientific laws. In the entire process of investigations, students are expected to acquire skills and knowledge such as the ability to design investigations, engage in scientific reasoning, manipulate equipment, record data, analyze results, and discuss their findings. To achieve this purpose of instruction, National Science Teachers Association (2007) recommend the inquiry-based laboratory investigation which is the process of asking questions and conducting experiments as a way to understand the natural world.

Inquiry-based laboratory investigations provide instruction with a priority on making observations and gathering evidence, much of which students experience in the lab or the field, to help students develop a deep understanding of the science content, as well as an understanding of the nature of science, the attitudes of science, and the skills of scientific reasoning. To address this, integration of inquiry-based laboratory investigations in the science lesson in every level of education starting from preschool to higher education should be achieved. As students move up to higher grades, the level of complexity of laboratory investigations should also increase. In the preschool and elementary level, students should be given opportunities to investigate appropriate questions, analyze the results of laboratory investigations, debate what the evidence means, construct an understanding of science concepts, and apply these concepts to the world around them.

As the students move up to the high school level, students should develop a growing understanding of the complexity and ambiguity of empirical work, as well as the skills to calibrate and troubleshoot equipment, understand measurement error; and have the skills to aggregate, interpret, and present the resulting data. They should also improve their ability to collaborate effectively with others in carrying out complex tasks, share the work of the task, assume different roles at different times, and contribute and respond to ideas.

At the tertiary level, students must learn how to work independently and collaboratively, incorporate and critique the published work of others in their communications, use scientific reasoning and appropriate laboratory techniques to define and solve problems, and draw and evaluate conclusions based on quantitative evidence.

To Domin (2009), all the expected outcomes are possible in science education. Learning about the methods and processes of scientific research (science process) and the knowledge derived through this process (science content) are expected as a well developed science education curriculum.. Science process involves direct interactions with the natural world in order to explain natural phenomena. Further, science education should include opportunities for students to learn about both the process and content of science and this is possible only through laboratory experiences.

Laboratory Experiences and Student Learning

The Committee on High School Laboratory, as cited by Singer, et al. (2005) in America's Lab Report, pointed out the importance of laboratory experiences of students in attaining the seven goals of laboratory instruction in science education. In typical laboratory experiences, students are engaged in one or two experiments followed by assessment to determine whether their understanding of science concept had increased. The Committee on High School Laboratory recommended integration of laboratory experiences into instructional sequences in order to help students progress toward science learning goals. In this way, student's learning about the concepts and processes of science are also integrated. This integration is referred to by the committee as the "integrated instructional units" which is designed to be learner-centered.

Integrated instructional units believed that effective instruction begin with what learners bring to the setting including cultural practices and beliefs, as well as knowledge of academic content. Students based their preconceptions of the natural phenomena on their everyday experiences in the world. These preconceptions are often reasonable and can provide satisfactory everyday explanations to students, but they do not always match scientific explanations thereby considered as intuitive ideas. Teachers are challenged with these intuitive ideas of students, they are challenged to help students move towards a more scientific understanding through change in and not merely an addition to what students notice and understand about the world.

The principle behind the integrated instructional units is that learning is enhanced when the environment is knowledge-centered. In the knowledge-centered environment, students learn with understanding rather than simply acquiring sets of disconnected facts and skills. There are two bodies of knowledge in science with which students must be engaged to – one is knowledge of accepted scientific ideas about natural phenomena and the other is understanding of what it means to "do science". These two aspects of science are reflected in the goals of laboratory experiences, which include mastery of subject matter (accepted scientific ideas about phenomena) and several goals related to the processes of science (understanding the complexity of empirical work, development of scientific reasoning). Student thinking about science shows a progression of ideas about scientific knowledge and how it is justified. At the first stage, students perceive scientific knowledge as right or wrong. Later, students characterize discrepant ideas and evidence as "mere opinion." Eventually, students recognize scientific knowledge as being justified by evidence derived through rigorous research.

Metacognitive strategies when implemented in a knowledge-centered environment will enable students to reflect on their own learning progress, to identify, monitor and regulate their own thinking and learning which in turn will facilitate their learning. To be effective problem solvers and learners, students need to determine what they already know and what else they need to know in any given situation, including when things are not going as expected. The basic metacognitive strategies include: (1) connecting new information to former knowledge, (2) selecting thinking strategies deliberately, and (3) monitoring one's progress during problem solving.

Furthermore, in a knowledge-centered learning, the practices and activities in which people engaged in while learning, shape what they learn. Transfer (the ability to apply learning in varying situations) is made possible to the extent that knowledge and learning are grounded in multiple contexts such as what transpires in the laboratory. Through multiple contexts, students can develop a deeper understanding of the concept and its use aside from they can acquire the ability to transfer what has been learned in one context to others.

Learning is enhanced in a community setting, when students and teachers share norms that value knowledge and participation (Cobb, Stephan, Clain & Gravemeijer, 2001). Such norms, Cobb further argued, increase people's opportunities and motivation to interact, receive feedback, and learn. It is said learning is enhanced when students have multiple opportunities to articulate their ideas to peers and to hear and discuss others' ideas. Such scenario can be achieved in integrated instructional units which are combined laboratory experiences and other types of science learning activities which may include lectures, reading, and discussion. If a classroom addresses quality norms, students are given more opportunities to frame their own research questions, design and execute experiments, gather and analyze data, and construct arguments and conclusions as they carry out investigations thereby making them independent learners. On the other hand, diagnostic and formative assessments are embedded into the instructional sequences and can be used to gauge student's developing understanding and to promote their self-reflection on their thinking.

The National Research Council (2005), in its report considered four principles of instructional design that can help laboratory experiences achieve their intended learning goals. These principles are (1) instructions must be design with clear learning outcomes in mind, (2) they must be thoughtfully sequenced into the flow of classroom science instruction, (3) they must integrate learning of science content with learning about the processes of science, and (4) they must incorporate ongoing student reflection and discussion. Combined with the seven goals, these principles offer better chances for students to experience worthwhile laboratory experiences. They provide a framework for curriculum developers, administrators, and teachers to use in reconsidering how laboratory experiences can be successfully incorporated into science courses.

Laboratory Instruction in Chemistry

As an experimental science, Chemistry depends heavily on experimental work as a strategy for teaching scientific principles and concepts and its development and application demand a high standard of performance of laboratory activities. Other than the expected results in student learning, laboratory activities allow students to appreciate and experience the constraints, potential and tensions of an investigative process which can only be experienced in the laboratory.

The laboratory is the most attractive place for the students to develop and show applications for general principles and techniques, says Wink, et al. (2000). It allows students to experience how the solution of real problems by people in all walks of life requires a thorough understanding of general chemistry principles. Bishop, Bishop & Whitten (2000) pointed out that the best way to acquire a deep, clear understanding of the nature of chemistry is in "hands-on" laboratory experiments with the real chemicals and real equipment which chemists use.

There are four reasons, according to Zulueta and Guimbatan (2002) for using the laboratory as a method of instruction in science, in particular, in teaching chemistry. Laboratory instruction in chemistry gives opportunities to students to manipulate concrete objects; participate actively; develop scientific competencies and motivation. Science involves the learning of highly complex and abstract subject matter. By allowing the students to have "hands-on experience", they understand and use scientific principles learned from the opportunity to manipulate actual objects and materials. Further, participating in a laboratory exercise gives students an appreciation of the methods of science and promotes problem-solving and other analytic competencies that can be generalized and applied to other areas. Students enjoy goal-oriented activities and practical work where they can see the relevance of abstract concepts and principles; and consequently, become interested in sciences and are motivated to learn more about discipline.

In addition, Walton as cited by Corpuz, Rimas, Galangco & Bautista (2003), gives the aims of laboratory method as to give firsthand experience in the laboratory which may increase student interest; to provide student participation in original research and to develop skills in the use of laboratory equipment and instruments.

Best Practices in Science Teaching

The National Research Council (2005) identified pedagogical practices which are considered truly best practices or authentic best practices in science teaching. Used in the science classrooms, there are significant evidences that show how these practices help students in learning better. These authentic best practices include: 1) Engaging resilient preconceptions. Students upon coming into the classroom have already initial understanding and preconceptions about the topic to be discuss. These preconceptions often limit what a student can learn so that it is important for a teacher to identify, confront and resolve this initial understanding. 2) Organizing knowledge around core concepts. All these best practices aim to increase understanding and retention of concepts among students by carefully and scientifically organizing information. For instance, students can readily remember a concept if they are taught how to recognize a certain pattern. In this way, teachers provide a foundation of factual knowledge and conceptual understanding to students. 3) Supporting metacognition and student self-regulation. This is making students assess themselves as to what they know and what they don't know. This could be done by requiring students to make a reflection that summarizes what they have learned or by administering a pre-test. In this way, students can take control of their learning.

On the other hand, Minstrell and Kraus (2005) enumerated the so-called best practices in science teaching which are based on ideology rather than on the findings of empirical research. These ideal practices which are often closely associated with students' success are:

- Establishing and maintaining classroom environments that are:
    - learner centered -- identifying, confronting, and resolving preconceptions, and beginning instruction with what students know.
    - knowledge centered -- focus on how something is know as much as what is known, and provide examples of what mastery looks like.
    - assessment centered -- make frequent attempts to make students' thinking and learning visible as a guide for further instruction.
    - community centered -- encourages a culture of questioning, including a bit of risk taking and respect for others

- Using an empirical approach
- Regularly employ active learning strategies
- Employ inquiry labs
- Talk about the nature of science
- Provide meaningful, engaged learning for all students.
- Provide an active approach to learning that includes a strong emphasis on student interaction with phenomena.
- Clear and explicit linkage between representations and phenomena represented.
- Engage students in challenging, authentic, interdisciplinary tasks.
- Provide opportunities for students to observe, explore, and test hypotheses.
- Eliminate discipline boundaries when natural, logical, and appropriate.
- Encourage the students' imagination, logic, and open-mindedness.
- Incorporate the content and processes of science giving due regard to science teaching standards.
- Give due regard to affective as well as cognitive domain.
- Link scientific concepts and processes with prior learning in science and other disciplines.
- Using a constructivist approach.
- Depth and breadth of coverage are reasonably balanced.
- Goals of tasks are conceptual and conceptual means are required to accomplish them.
- Assigning manageable tasks
- Setting high expectations
- Engage all learners in meaningful scientific tasks involving high-order thinking skills.
- Providing and receiving feedback
- Accommodating student learning styles
- Teaching in a way that is consistent with student development
- Including real-world applications in the learning process
- Using individual and group motivation
- Moving from concrete to abstract
- Requiring practice of learned skills
- Employing learning cycles - observation, generalization, verification, application
- Making use of multiple intelligences
- Establishing conducive learning environments
- Encouraging student evaluation of alternative hypotheses
- Addressing conceptual goals and means
- Eliciting and addressing misconceptions
- Promoting critical thinking
- Creating, sharing, and using scoring rubrics
- Aligning objectives, instruction, and assessment
- Focusing on depth in addition to breadth of coverage
- Placing strong emphasis on interaction with phenomena
- Making clear and explicit linkage of representations to phenomena
- Using multiple representations of physical phenomena
- Employing Socratic dialogues

Different approaches are employed by laboratory instructors in teaching chemistry laboratory, but all these approaches have an end goal of making students enjoy, understand, participate and develop skills. Aquino (2003) enumerated the three objectives of science teaching as the development of science process skills, scientific attitudes, and literacy. On the other hand, Salandanan (2002) stated that students should be able to achieve the different goals of science teaching such as the development of scientific attitudes and values; enhancement of skills in employing a systematic and scientific methodology; gaining an understanding of functional knowledge; arousing further interest in science-based pursuits; and development of desirable social attitudes.

In any teaching strategy in the laboratory, students must be given the opportunity to develop critical and analytical mind. Teachers must engage in practices that will arouse the curiosity of students by encouraging them to ask questions. Creativity and resourcefulness could be inculcated into the students by stimulating them to generate new ideas and original ways of doing things. Other wholesome attitudes should be develop by students through awakening their interest and keeping them highly motivated to inquire about occurrence in the natural environment. They must learn to make fair and unbiased decisions, accept evidences, suggestions, and alternatives in the light of new discoveries. They must relentlessly pursue an investigation and be responsible enough to complete an assigned task despite constraints. They must have constant practice in experiencing step-by-step procedure to find answers to their endless questions.

Encouraging students to participate actively in planned experiments might be daunting for the students, however it will definitely enable them to acquire functional knowledge which can be applied in solving problem situations in the environment instead of knowledge which is merely memorized and easily forgotten. Another best practice in the teaching of science is the treatment of life experiences as necessary tools to motivate students to participate in classroom activities. These learning experiences might include joining movements in science promotions, protection and care of the environment and natural resources, as well as helping decide on issues of nationwide interest. Experts are saying that given the correct avenue to express and explore these life experiences, there is a strong chance that students will decide to pursue a science profession in the future and will develop a feeling of gratitude and appreciation for the advances in science and technology that continue to raise the present quality of life. Further, when students are allowed to experience more group investigations, positive attitudes could be developed among students such as tolerance, respect for the opinions of others and willingness to accept criticisms and suggestions, learning to cooperate with others, willingness to share findings and resources and the readiness to extend expertise.

Laboratory Method. The laboratory method according to Acero, et al. (2000) deals with experimentation, observation or application by individuals or small groups dealing with actual materials. There are two types of laboratory method; the experimental and the observational method. They differ in aims and emphasis in the sense that experimental method aims to train pupils in problem-solving with incidental acquisition of information and motor skill while observational method aims on the acquisition of facts. As to emphasis, experimental method is focussed on discovery, original procedure, analysis, and solution of problems while in observational the emphasis is on the acquisition of facts through activities such as visits to museums, exhibits, and art galleries, watching demonstration, listening to lectures, viewing films, and going on field trips.

Laboratory method consists of three steps: the introductory step, work period and the culminating activities. In the process, introductory step aimed at orientation and motivation where determination of work to be done is presented. The work period is defined as a supervised period where students gain experience in the scientific procedure, handling raw materials, and using tools while working on the same problem or on different problems on their own. In the culminating activities, students discuss and organize their individual findings after completion of the work. They present the results by a) explaining the nature and importance of the problem the group had worked on; b) reporting data gathered on other findings; c) presenting illustrative materials or special contributions; d) special reporting and exhibition of work by those with individual projects; and finally, e) exhibiting various projects and explanations by their sponsors.

To Hidalgo (2000), classroom strategy which uses laboratory method has an advantage over other methods because students are learning by doing since actual experience is vivid. When this happens, the learning gained is retained longer; reality is more vivid than any symbol; and it is a direct preparation for a new way of life. Hidalgo (2000) gave suggestions to the laboratory teachers on the better way of handling laboratory classes. For an efficient delivery of lesson, Hidalgo (2000) opines that teachers should adapt laboratory exercises to the needs, interest and capacities of students. To address reflected thinking, laboratory exercise must grow out of problems so that a recipe-type activity is not recommended. Another good practice for a laboratory teacher is to require students to keep a laboratory notebook where they can record not only the results of their investigations but also the learning they got from the experiment.

For his part, Domin (2009) described four types of laboratory instructions: expository (traditional), problem based, discovery and inquiry-based. Domin (2009) explains that they differ in outcome, approach and procedure. Expository, problem based and discovery laboratories all have predetermined outcomes because he emphasized, the expected results are already known. However, the limitation is pegged on the fact that it is only the teacher who knows the outcome in the discovery and problem based unlike in the expository where both the teacher and students know the expected result before doing any activity. In the inquiry-based instructions, meanwhile, neither the teacher nor the students know the outcome of the experiment. Given this, therefore, the choice of instruction is crucial to achieve life-long learning among the students.

The study conducted by the National Science Teachers Association (2007) reveals that laboratory investigations must be adapted to the age and ability levels of students. They should not be the recipe-type activity that is somewhat related to the instructional sequence of the topics discussed in the lecture. Well designed laboratory investigations are those in which the objectives of the activity are clearly communicated to students and which focus on science processes and integrate student reflection and discussion. Finally, the designed objectives give the students the opportunities to develop safe and conscientious laboratory habits and procedures.

Experimenting. An experiment (Salandanan, 2002) is "described as a learning activity wherein a student investigates a problem by manipulating a variable." Salandanan (2002) listed the reasons why experiments are done: a) to develop basic science process skills; b) to cultivate an inquiry mind; c) to acquire higher-order thinking skills like critical thinking, creativity and inventiveness; d) "learning by doing" forms part of the students attitudes, habits, and ways of reacting; e) to internalize and instantly apply in solving problem situations f) to replace hearsay, superstitions, and unfounded beliefs by more objective assessment and evaluation; g) to make students appreciate and be grateful for the achievements of scientists; and h) to make students responsible for their own learning by completing the assigned tasks.

For an experiment to be successful, it is argued that the students must clearly understand the problem; variables must be tested one at a time; students must participate actively in manipulating tools, materials and equipment. Any absent component would mean that the classroom will not be successful. On the part of the teacher, the teacher must be a keen observant who can easily spot incorrect steps and procedure to be able to encourage the use of improvised materials to promote resourcefulness and creativity and to underscore the important elements of classroom setting.

Demonstration Method. Still, Hidalgo (2000) defined demonstration method as the "planned manipulation of materials and equipment to the end that students are able to observe all or at least some of the manifestations of one or more scientific principles operating within a phenomenon." Demonstration method differs from experimenting because it is content oriented while experimenting is process oriented. It simply reinforces the previous learning and aims toward a summary of ideas while experimenting aims to solve problems and gain new learning. Therefore, Hidalgo (2000) summarizes, "demonstration method is used when time and equipment are limited and the process can be described as complicated or difficult while experimenting is used when the purpose of the classroom is to develop resourcefulness among students."

Demonstration method is considered as an excellent method to motivate and arouse the interests of students in introducing any new lesson. On the other hand, Garcia as cited by Acero, et al. (2000) called demonstration method as imitative method where learning a skill is faster and more effective since the students are shown how the job is done by using the actual tools, machines, and materials.

Discovery Method. The discovery method is a teaching strategy in which objectives help the student to learn through self-discovery (Corpuz, et al., 2003). In this type of classroom, the teacher prepares a class situation where students are led to find answers or solutions to a problem on their own. Further, discovery method employs the inductive approach wherein the teacher asks thought-provoking questions before performing an experiment to allow for self introspection and analysis.

The discovery classroom, says Hidalgo (2000) demands for the teacher to cultivate among the students an attitude of trying to solve problems on their own even if it would result in failure than not trying at all. Hidalgo (2000) further suggested that teachers allow for independent learning to allow for more learning.

With all these benefits an educator gets from the discovery method, Corpuz, et al. (2003) opined that it is an extremely effective method. The most important gain it gives to the learners is the feeling of satisfaction and joy for the students in discovering new learning and concepts.

Inquiry Approach. The goal of inquiry teaching according to Salandanan (2002) is "to make children learn how scientists learn, and in the process, learn science." Further, it aims to encourage students to rely to a greater extent on their own resources. In fact, in using the inquiry approach, learning leads to the attainment of one of the most significant outcomes of science teaching- that is, developing a scientific mind while not undermining the desirable social values. Students develop traits such as critical-mindedness, objectivity, and rationality while engaged in an inquiry approach. They become more cooperative, tolerant, and considerate in dealing with others because of constant involvement in group activities, thereby making them highly motivated.

In his study, Straatman (2006) made use of inquiry methods in laboratory activities and demonstrations along with traditional teacher-focused methods. A variety of data collection methods were used to investigate changes that occurred in his approach to teaching chemistry especially in relation to questioning strategies. The study revealed effects of inquiry techniques on students' problem-solving and logical thinking skills. His study enabled him to take a more in depth look at how teaching methods affect student learning.

Process Method. Hidalgo (2000) defined process as "a method of doing something; a systematic and interdependent action of things related to a discovery approach where at the end things are attained." In the science classroom, scientific activities are processes or methods and the scientific information is the product of the process. Laboratory investigation, for example, is a process of making a discovery where students become more actively involved.

Small Group Instruction. This method of instruction enables the teachers to give more individual attention to each student's learning needs. In small groups, the students become more actively involved in their own learning and participate more freely in discussions. (Hidalgo, 2000). In this method, students leadership is develop aside from they learn the skills of discussion and group processes. This method enhances cooperation, team work, and group motivation among students.

Principles of Best Practice Learning

Zemelman, Daniels & Hyde (2005) claims that there are classroom practices which need to be enhanced to be implemented more often while there are those which should be implemented in a lesser frequency. In a bigger concept, therefore, there must be less implementation of teacher-directed instruction like lecturing; student passivity like sitting, listening, receiving, and absorbing information; presentational or one-way transmission of information from teacher to student; prizing and rewarding of silence in the classroom; classroom time devoted to fill-in-the-blank worksheets, dittos, workbooks, and other "seatwork"; student time spent reading textbooks and basal readers; attempts by teachers to thinly "cover" large amounts of material in every subject area; rote memorization of facts and details; emphasis on the competition and grades in school; tracking or leveling students into "ability groups"; use of pull-out special programs; and use of and reliance on standardized tests.

In contrast, he recommended the frequent or more implementation of experiential, inductive, hands-on learning; active learning, with all the attendant noise and movement of students doing, talking, and collaborating; diverse roles for teachers, including coaching, demonstrating, and modeling; emphasis on higher-order thinking; learning a field's key concepts and principles; deep study of a smaller number of topics, so that students internalize the field's way of inquiry; reading of real texts: whole books, primary sources, and nonfiction materials; responsibility transferred to students for their work like goal setting, record keeping, monitoring, sharing, exhibiting, and evaluating; choice for students (e.g., choosing their own books, writing topics, team partners, and research projects); enacting and modeling of the principles of democracy in school; attention to affective needs and varying cognitive styles of individual students; cooperative, collaborative activity; developing the classroom as an interdependent community; heterogeneous classrooms where individual needs are met through individualized activities, not segregation of bodies; delivery of special help to students in regular classrooms; varied and cooperative roles for teachers, parents, and administrators; reliance on descriptive evaluations of student growth, including observational/anecdotal records, conference notes, and performance assessment rubrics.

From those practices which he recommended to be implemented more and those which need to be implemented less, he then identified thirteen principles characterizing a model education. These principles are interrelated and are actually influencing each other. These practices, he pointed out are student-centered, experiential holistic, authentic, challenging, cognitive, developmental, constructivist, expressive, reflective, social, collaborative and democratic.

In a student-centered learning environment, teachers must consider the real interest of students, taking their own questions into precedence over other selected content. At some point, it involves building on the natural curiosity of students and asking them what they want to learn. Teachers must guide their students in solving their own questions by structuring for them widening circles of experiences and investigations. At this point, the teachers serve as facilitators understanding deeply the needs and experiences of their students in order to design enjoyable and engaging activities.

In an experiential learning, students are given the opportunities to experience the most powerful and natural form of learning which is acquired through doing instead of just hearing. Students must be engaged in active, hands-on, and concrete experiences such as conducting experiments, going on field trips to investigate natural settings, pollution problems, and laboratories at nearby factories, universities or hospitals.

If planned properly, holistic learning is possible when students encounter whole ideas, events, and materials in purposeful contexts, instead of studying isolated subparts from actual use. Information and ideas must not be presented to students in small "building blocks" because this part-to-whole approach undercuts motivation for learning since students don't perceive why they are doing such things. Students should not be deprived of an essential condition for learning, that is encountering material in its full, lifelike context.

Linking learning to real life concepts is considered authentic teaching which integrates real, rich complex ideas and materials in contrast to the lessons or textbooks that disempower students. Experts all agree that learning becomes meaningful when students are faced with genuine challenges, choices and responsibility while learning independently. There is cognitive learning when students acquire true understanding of concepts using higher order thinking associated with various fields of inquiry and through self monitoring of their cognition and mental processes. Learning activities should fit the developmental level of students, therefore they must be taught in a constructivist approach by making them recreate and reinvent every cognitive system they encounter. Students must also be trained to employ regularly the whole range of communicative media to fully express ideas, construct meaning and remember information. Opportunities to reflect, debrief, and abstract from students' experiences what they have felt and thought and learned should also be provided for a more effective learning environment. Teachers need to create classroom interactions which are socially constructed to show that learning can be achieved through collaboration to eliminate competition and individualistic approaches. Democratic learning makes the classroom a model community where students learn what they live as citizens of the school.

Principles of Effective Laboratory Experiences

In 2008**,** Jona, et al. Emphasized the four curriculum standards that were identified as principles of effective laboratory experiences by the National Research Council (2005). These are clearly communicated purposes; sequenced into the flow of instruction; integrated learning of science concepts and processes; and ongoing discussion and reflection.

In National Research Council's landmark study (2005), laboratory experiences are considered effective if they have clear learning goals that guide the design of the learning experience. The teacher must communicate clearly the purpose of the activity so that students can successfully carry it out and achieve the desired goals set. It is recommended to design an inquiry activity where students learn specific concepts which are clearly communicated to them throughout the learning and discovery process. At the end, they will be assessed on their ability to achieve the instructional purpose of the activity.

Still in the results of the study, laboratory experiences are said to be sequenced into the flow of classroom science instruction if they are explicitly linked to what has come before and what will come after. Scientific investigations when integrated into a well-designed sequence of instruction will serve as an instructional purpose that is consistent with the objectives of the learning unit. To achieve this, laboratory teachers must give their students ample time to discuss the activities they are engaged in during laboratory period and reflect on the meaning they can make out of them. They must also be given opportunities to formulate hypotheses before experimentation so that they can reflect on their ideas after the complex process of experimentation. A knowledge-centered environment is created when students reflect on their own learning progress, when they identify, monitor and regulate their own thinking and learning. Metacognitive strategies must be implemented by laboratory teachers in a way that students can determine what they already know and what else they need to know in any given situation including when things are not going as expected.

Teaching of Nature of Science

Crowther, Lederman & Lederman (2005) suggested some teaching strategies that will highlight the teaching of nature of science. Teachers can design lessons around science topics or concepts that have changed over time and the instruction must be explicit on how knowledge has changed and why. Through this, students will learn that scientific knowledge in and of itself is not static and that with new information, scientific theories can change. However, students must be taught also that some laws in science have stood the test of time. In teaching scientific laws, teachers must emphasize how these laws describe nature and how things act under certain conditions. Also, the manner a teacher poses questions inside the classroom lead to investigation and experiments then will eventually lead to conclusions **-** but still there are many different pathways that scientists take. In conclusion, it is incorrect to assume that all scientific investigations follow the same set and sequence of steps. One of the reasons why knowledge is subject to change is that these different types of investigations provide different information and evidence concerning the natural world, hence, different learning outcomes.

Motivation and Attitude Toward Science

Students in the tertiary level of education are required to take an introductory science course as general education subject. It is not surprising that some students do not succeed because they just enroll the subject for requirement purposes rather than taking the subject because they have a passionate interest for learning it. It is the concern of the science instructor to shape the attitudes of students toward science so that they leave their classes with positive views of the discipline.

A possible reason why students seem not to learn much concepts on science subjects is that most instructors focus primarily on content of the subject instead of helping learners cultivate a holistic attitude towards the subject. The pedagogic strategies of the teacher also play an important role in how students will appreciate science subjects.

Still, there are other factors which may result in negative attitudes towards science: "lack of needed skills to learn and apply scientific concepts, lack of motivation to work hard in science classes, home backgrounds, school and classroom environments, biases of peer groups, the media's portrayal of scientists, and students' perceptions of rewards associated with learning, science anxiety, the fear of science learning, and apprehension toward scientists and science-related activities."

Previous experiences of students also affect the attitude of students toward science as a subject and as a body of knowledge. It has been argued that to build motivation and positive attitude among students, there must be a good understanding of the content being taught, therefore the teacher must find ways to probe knowledge which the students have previously constructed. If the prior knowledge of the student is insufficient, inaccurate and in conflict with what is being taught, the teacher, then must guide the students in reconstructing their knowledge. Learning that will give the opportunity to student to reconstruct their own conceptual knowledge and understanding leads to a lasting improvement in students' attitudes greater chances of success in their studies and lives.

The attitude of a student toward a subject has something to do with the motivation made by the teacher in introducing a lesson. Positive attitudes develop if a student is highly motivated and this can be done by the teacher through improving the teaching practices and by showing to the students the relevance of the topic to their everyday lives. Teachers must create a learning environment that will encourage and inspire the students not only to come to class regularly but also to have a desire to learn and enjoy learning.

Movahedzadeh (2011) suggested some teaching practices that will motivate the students and will lead to their positive attitude towards the subject. Teachers must consider the preconceptions of students regarding the topic by asking them of their personal views so that diversity of views in the class lead to a deeper discussion about the process of doing science, the application of scientific discoveries, and the impact of science on society.

The relevance of science can be further emphasized to students by mobilizing the scientific and engineering research community. When students are given access to practicing scientist and engineers who can provide them with valuable information on careers and studies, students would increase their interest and enthusiasm in learning science concepts. For the students, inviting experts in the class would help to put the subject into context and make classroom activities more exciting. It is not only school visits of professionals but also visit of students to the workplaces of these professionals that will help them to learn about and understand specific professions.

Brodie (2006) even proposed some projects that will increase student participation, motivation and success by involving the whole scientific community. These are the "Researchers in Residence Project," "Express Yourself Conferences" and creating Centre for Science Education. In the "Researchers in Residence Project," creative research talents such as PhD students and post-doctoral researchers in science, technology, engineering and mathematics share their passion for their field of specialization to the students for the purpose of igniting a fresh interest for science among young people. Through the involvement of these research talents who act as positive role models, significant change occur in how people view scientific researches, scientists, and technical aspects of science.

The project dubbed as "Express Yourself Conferences" hopes to enable students to present the findings of their own science investigations. In these designed conferences, students are given opportunities to communicate and share their ideas with other students, teachers and researchers; present research papers in seminars chaired by researchers in residence; present and host displays of their investigations; and participate in other activities, such as discussing their work with experienced researchers, attending keynote lectures and demonstrations, and participating in practical workshops. On the other hand, the Centre for Science Education is created for the purpose of inspiring and capturing the imagination of young people in science through the development of 'creativity-rich' resources and activities. In this way, students will be motivated to pursue science courses and to be successful in their chosen career.

With the same purpose and intention, Wilson, Cordry & Uline (2004) said that participation of students in science fairs will promote positive attitude towards science because in doing science fair projects, students find enjoyment in applying scientific method thereby promoting their interest in science. It also develop student's sense of personal capabilities and qualities and appreciation for nature and the relevance of science in daily life.

A study was conducted by Hall (2006) on the techniques to encourage students to confidently contribute to their lab groups in science classrooms. She observed her students during laboratory and analyzed how they conduct themselves. A new system was implemented where students were assigned specific roles during laboratory and a grade was given based on their level of contribution to the lab group. As a generalization, her data showed a positive relationship between the implemented treatment and more active science lab participation.

Another study, that of Washtak in 2006, examined the use of technology in both the lecture and laboratory settings of a high school chemistry class. The focus of her study was on the student motivation and ability to learn from technology. As variables of the study, PowerPoint, SMART Board and computer animations were used in the lecture setting. Logger Pro software and individual laptops were used in the laboratory setting. The assessment techniques included pre- and post-tests, surveys, teacher journal, analysis of specific test and laboratory questions, student interviews and comparison of test scores, results of which found students motivated by technology and were able to learn from them.

In an action research spearheaded by Nordick (2006), he introduced a unit plan that included detailed lecture guides. Each guide contained objectives, key terms, and important topics for students to follow during lectures. Such lecture guides were organized into unit plans and presented to the students prior to the beginning of each unit.

In another study, the effect of having older students teach science concepts to younger students was given focus. Muchmore (2006) looked into the argument whether students reach higher levels of achievement when they take on the teacher role versus that of student roles. After observing a dramatic rise in student participation in cooperative groups, Muchmore (2006) recognized the importance of active student engagement and responsibility for learning. Evidence indicated that peer assisted learning did, in fact, increase student interest, however, a thorough investigation on better ways for students to retain learning was recommended.

Mentzer (2006) also explored on how student motivation, as defined by validity and self-efficacy, was affected by journaling, and if that motivation affected the time it took students to get ready for class. His study revealed that a short period intended for journal writing before classes begin, spell a big difference in students' learning.

Eastwell and Rennie (2002) for their part used a quasi-longitudinal case study to determine the effects on secondary students of participation in a program of enrichment and extracurricular science activities in terms of their interest and enjoyment in being involved in science activities, their motivation to continue to participate in science, and their perceptions about scientists and about the role of science in society. A strong positive relationship was found between changes in students' interest and enjoyment and changes in their motivation, and both these variables increased, in an overall sense for the combined student population, during the study period. All students generally held a high perception of both the normality of scientists and the importance of science in society throughout the study period. Participation in science activities impacted overall positively, but to varying extents for different activities, on all four dependent variables. Suggestions for the structure and/or conduct of competitions, excursions, and practical work, including the design of museum exhibits, and implications for further research are presented.

A study with focus on integrating graphic organizers in the attitude, perception and achievement of students in chemistry was done by Torres (2009). The results of the study proved that student's prior knowledge of outlining format allowed them to more easily utilize and organize information. In addition, the sequencing and planning of instruction by the teacher in an outline format allowed students to extract and synthesis information in an organized manner.

Science Laboratory Skills

A well-designed laboratory activity has the potential to motivate students, support meaningful learning of concepts, and develop manipulative competencies among students. According to Moni, Hryeiw, Poronnik, Lluka & Moni (2007), students must be taught of the differences among "knowing about" a topic, "knowing how" to complete a skill, "showing how" to complete a skill, and finally "doing" the skill. This is possible through integration of skills development with conceptual learning. Skills were considered as "embedded elements of the more complex laboratory practices of problem-based or case-based inquiry learning tasks." (Moni, et al., 2007). Skills can be further differentiated from practices by saying that skills represent "hands-on" or "doing" while practices represent the combination of "hands-on' and "minds-on." With this difference, teachers must teach skills to students with the expectation that competencies in skills would support open-ended, student-driven explorations.

Kanli and Yagbasan (2008) identified laboratory principles for teachers which cover laboratory teaching approaches to develop science process skills and conceptual achievement among students. According to them, teachers must practice the principles of knowing how to excite, explore, explain, elaborate, extend, exchange, and evaluate students. They enumerated teaching practices under each principle. To excite students, teachers must provide the students with the thoughts of the first scientist and make them feel like them; intrigue to ensure students' participation (a simulation may be watched about experiments); make a spark about the subject; try to discover what students know about new concept or subject; ask questions that may confuse minds (create unbalance); and ask questions about misconception.

In the field, science teachers explore when they provide environment for concrete, tangible activities that include skills and concepts; ask probing question; listen and observe students; just play the role of a good adviser or coach in students' journey to cognitive balance; create a rubric that will evaluate the skills of students about determining variables and establishing hypothesis; and ensure that the students save the data they acquired correctly.

Another laboratory principle students must learn from the classroom interaction is the ability to explain. Teachers must encourage students to explain and determine concepts; demand explanations and proofs from students; emphasize that students use the data they acquired to make reasonable explanations; and bring forward new concepts by taking students prior experiences and making explanations and definitions.

This is possible, Kanli and Yagbasan (2008) noted if the teacher explores on the elaboration of ideas and topics in the classroom. A teacher can elaborate the topic if she encourages students to apply concepts and skills into new situations; demand from students to use concepts, explanations and definitions with the previously acquired ones. A teacher values exploration in her classroom if the students become aware that proofs and data are necessary in proving one's opinion or point. The classroom, as a main source of knowledge, must ensure that the students extend their learning by guiding them in associating present concepts with other fields and/or other concepts/subjects. Further, a teacher may also ask research questions to help them in associating the current lesson to concepts/subjects of other fields. Teachers must also teach to their students the principle of exchange by preparing proper environment for students to discuss their ideas with their friends; observing and listening to the students who are sharing their knowledge; and ensuring the interaction within student groups, competing student ideas. Lastly, teachers must know how to evaluate their students' learning by observing students that apply new concepts and skills; evaluating knowledge and skills of students; searching the reasons of students' changes of attitudes and ideas; letting the students evaluate their knowledge and group process skills; and asking the open-end questions such as "Why did you think like that?", "What is your proof for this?", "What do you know about ....?", "How do you explain...?"

Achievement in Science

Successful teaching and learning of science is the product of the correct use of an appropriate teaching method whose objectives focus on the high achievement of the learners. One of the challenges of a science teacher is how to facilitate learning which will address the difficulties of the learners in assimilating concepts. Wachanga and Mwangi (2004) stated that knowledge about teaching methods affect students' learning may help educators in selecting methods that will improve teaching quality, effectiveness, and accountability to learners and the public. To be an effective teacher, students must be given opportunities to learn and technically manage instruction. Effective learning and students' achievement will be enhanced if students are allowed to use their hands, eyes, ears and their mind.

In the Cooperative Class Experiment Teaching Method, Wachanga and Mwangi (2004) reflected on how students acquire greater mastery of the subject matter because of peer teaching. Aside from generating better intergroup relations, "the shared responsibility and interaction in this method result in better self-images for students with histories of poor achievement" (Wachanga and Mwangi, 2004). Slow learners, moreover, benefit in this cooperative learning method because fast learners share their ideas so that the others learn the ideas in depth and remember them longer.

In a science classroom, on the other hand, well-managed laboratory activities in enhancing student's learning of science concepts result in an enhanced interest in science (Claveria, 2002). Students prefer experimenting, demonstrating, film showing using instructional media, making diagrams, drawings, painting and sketches, gathering clippings of inventions and significant science events classifying plants and animals through pictures and observing prepared slides and specimens to enhance student's interest in science, collecting rocks, taking photographs of nature, collecting variations of plants and animals and preparing botanical gardens. Furthermore, she recommended that student's interest in science should be maintained by inviting young scientists from whom they can draw further inspiration. The teachers should be updated on the new techniques and trends in teaching science subjects, so they could be more creative and resourceful. In addition, the teachers should teach their students to improvise science materials that they can use in the laboratory activities.

To prove such theory, Ricardo (2008) conducted a study on how chemistry is taught in the public secondary schools to determine the factors affecting students' performance. To gather enough data, Ricardo (2008) did actual observations, supplemented by interviews with the teacher, head teacher, and principal. In his observation, the predominant teaching strategy used by most teachers is still lecture-discussion, a traditional method. A significant correlation existed between the performance of students in the achievement test and the method by which chemistry is taught.

The effects of Task-Oriented Learning Approach (TOLA) on chemistry achievement among self-handicapping students were analyzed by Reyes in 2002. TOLA consisted of several components like task-on-activity, developing collaborative skills, classroom management strategies and self-assessment. Self-handicapping students are those who are complaining about the subject, avoiding seeking help, avoiding taking risk in difficult task, withdrawing effort, reducing performance setting, lacking in preparation, procrastinating and making excuses. The results showed that TOLA consistently improved the achievement of self-handicapping students in chemistry.

Roble-Estrella (2009) suggested some teaching strategies in chemistry laboratory that will enhance the performance of students in the laboratory in her research. For her, the teacher must state the objectives clearly in every laboratory activity; emphasize major ideas as they are presented; provide step-by-step directions when necessary; check for understanding at intervals before proceeding to the next major idea or concept; provide concrete examples to explain and reinforce information; use appropriate scientific vocabulary; must be specific and precise by referring to concrete objects and events; ask questions or obtain work samples before proceeding to the next procedure; call on slower students and non-volunteers and print out necessary parts of the activity. Her study supports other researches on best practices to enhance the learning capabilities of students enrolled in science subjects.

In the study by Palada (2002), the level of performance of students in chemistry is found to be significantly influenced by their perception about chemistry and by the teacher's most preferred teaching practice as perceived by the students. She further concluded that teaching practice influences the academic performance outcome of the teaching process. "Knowledge of content and understanding of student's strengths and weaknesses along with appropriate teaching practices can improve teaching and result to higher student's achievement" (Palada, 2002).

For her part, Leonor (2007) used the Scientific Inquiry Method to determine the extent of academic performance in chemistry of students. She enumerated techniques which are considered to be included in the scientific inquiry method. These include the limitation in the use of lecture and direct instruction in presenting the lesson; use of student's prior knowledge as basis for introducing new concepts; exploring student's interest to make learning relevant and meaningful; using inquiries and investigations to anchor new information to previously held knowledge; initiating classroom dialogue and discourse by posing essential or starter questions; asking questions that require higher order thinking skills and critical skills; using wait time techniques appropriately and not interrupting students in the middle of their questions or answer; rephrasing students' questions and answers; establishing everyday routines for group interaction; arranging student's desks for collaborative work in small groups; focusing the lesson on engaging and relevant problem-solving situations; encouraging students to design and carry out their own investigations; integrating science content with process skills and problem solving strategies; valuing student's responses and viewing wrong answers as an open door to their misconceptions; encouraging students to use concept maps; graphic organizers; and drawings of models to explain and demonstrate newly acquired knowledge.

Synthesis

The present study attempted to explore the different practices in chemistry laboratory instruction that were expected to attain positive attitudes of students towards learning chemistry, competencies in the laboratory skills and high achievement in the subject. In particular, this present study bears similar concepts and focus to that of Hall (2006); Washtak (2006); Mentzer (2006); Eastwell and Rennie (2002); and Claveria (2002) in that they looked into how teachers deliver their lessons for the enhancement of the interest of students in learning science.

There is a similarity between the present study and the studies of Palada (2002); Straatman (2006); Nordick (2006); Ricardo (2008); and Roble-Estrella (2009) because they focussed on the teaching strategies for the development of various skills of students in science subjects.

Lastly, Reyes (2002); Muchmore (2006); Leonor (2007) and Torres (2009) focussed their studies on how teaching practices influence the achievement of the students in science subject similar to the present study.

Research Design

This study employed the descriptive design, particularly the qualitative-quantitative method of research which according to Alasuutari (2004) is that type of research which "involves checking of data collected via one method with data collected using another." The main objective of the study was to propose a model of a teaching-learning process based on the best practices in chemistry laboratory instruction. The descriptive design was the most appropriate design to be used in determining the best practices in chemistry laboratory instruction that will attain the goals of science lab instruction. These were investigated through qualitative method in which a focus group interview of faculty and students followed by class observations were conducted. Quantitative method was used in determining the students' manifestation of the attainment of the seven goals of science laboratory instruction through administration of instruments such as Attitude/Motivation Instrument, Practical Test and Achievement Test.

Research Locale

This study was conducted at Lyceum of the Philippines University in Batangas, Laguna, Cavite and Manila. LPU, an institution of higher learning, inspired by the ideals of former Philippine President Jose P. Laurel, is committed to the advancement of his philosophy and values "Veritas et Fortitudo" (truth and fortitude) and "Pro Deo et Patria" (for God and Country). Guided by its vision and mission, it aims to provide quality education through its three-fold function of instruction, research and community extension. It offers various programs in science where General Chemistry is one of the basic subjects. General Chemistry is a five unit subject comprising of three hours lecture and three hours laboratory in a week.

Participants of the Study

This study involved teachers and students from the four universities of the Lyceum University System (LPU in Batangas, Laguna, Cavite and Manila). The participants were chemistry faculty and their students enrolled in General Chemistry during the second semester of the school year 2011 - 2012. The chosen faculty have been teaching chemistry for a minimum of three years and were either chemical engineers or chemists by profession. Most of them have Masters' degrees. The students, on the other hand, belong to degree programs such as B.S. Physical Therapy, B.S. Psychology, B.S. Engineering, and A.B. Mass Communication. Majority of the student-respondents were first time takers of the subject, however, some of them were repeaters.

Two to six chemistry faculty from each university and a group of three to nine chemistry students participated in the focus group interview. The profile of faculty was secured from the Human Resource Office of the university to find out who among them are science majors. The faculty-respondents were selected from the faculty of sciences. This faculty is responsible for teaching chemistry in the university. The students who were interviewed were selected from the students who were enrolled in General Chemistry during the second semester. About thirty percent of the class or three to nine students were selected randomly from the class based on the total number of students in each chemistry class.

Class observations were also done to further validate data gathered from interviews and focus group discussions. A total of four faculty from the four universities were observed and a total of 80 students responded to the administered questionnaires. The Achievement Test, Practical Test and Attitude/Motivation Questionnaire were administered to the intact class of the observed faculty at the end of the semester.

Data Gathering Instrument

To approximate the best teaching practices employed by the faculty in teaching chemistry laboratory, five instruments were developed by the researcher and were content validated by experts. They were developed after a thorough review of conceptual literature about best teaching practices.

Focus Group Interview Questionnaire for Faculty and for Students. This instrument was prepared to approximate if the chemistry faculty is implementing practices in teaching chemistry laboratory which will lead to the attainment of the seven goals of science laboratory instruction (See Appendix H- Appendix I). It was a structured questionnaire consisting of open-ended questions which were answered by a group of chemistry faculty and a group of students. The items were classified according to the goals of science lab instruction. The items were intended to get information on the enhancement of mastery of subject matter, the development of scientific reasoning, the development of the students' understanding of the complexity and ambiguity of empirical work, the development of practical skills, the students' understanding of the nature of science, the cultivation of interest in science and in interest in learning science, and the development of teamwork skills. The questionnaire was presented to the advisers for comments and suggestions and then to three chemistry experts for face and content validity.

Observation Checklist. This checklist was used in conducting unannounced class observation to validate if the faculty concerned is practicing the good instruction in conducting chemistry laboratory classes mentioned in focus group discussions and to see if the seven goals of science instruction are manifested in their teaching practices (See Appendix J). The items in the observation checklist were classified according to the goals of science laboratory instruction. The content of the checklist was similar to the content of the focus group interview questionnaire. The items were enumerated so that the observer can take note of the practices implemented by the faculty after thirty minutes, after two hours and at the end of the class. Like that of the previous instrument, the questionnaire was presented to the advisers for comments and suggestions and to three chemistry experts for face and content validity. The following scale range was used to interpret the data gathered by the questionnaire.

Scale Range	Verbal Interpretation
2.28 – 3.00	always practiced
1.52 – 2.27	often practiced
0.76 – 1.51	sometimes practiced
0 – 0.75	never practiced

Note: A mean of 1.52 to 3.00 is an indication that the faculty is implementing the best teaching practices that will lead to the attainment of the seven goals of science lab instruction.

Attitude/Motivation Instrument. To approximate the extent by which students manifest the attainment of the goals of science laboratory instruction in their attitude and motivation, an attitude/motivation instrument was constructed by the researcher. This Likert Scale Instrument (See Appendix L) consisted of 15 items which were categorized as to the views of students about learning chemistry (attitude) or interest in learning chemistry (motivation). Seven items of the questionnaire determined the student's attitude towards chemistry and eight items determined their motivation. The instrument also approximates the students' understanding of the nature of science. The students were asked to chose from a five-scale option such as strongly disagree, disagree, neither agree nor disagree, agree and strongly agree. Equally, face and content validity were established for this instrument. Interpretation of the data yielded by this attitude/motivation questionnaire was based on the following scale range:

Scale Range	Verbal Interpretation
4.51 – 5.00	Very positive attitude Very highly motivated Very much understood
3.51 – 4.50	Positive attitude Highly motivated Much understood
2.51 – 3.50	Moderately positive attitude Moderately motivated Moderately understood
1.51 – 2.50	Negative attitude Lowly motivated Not so understood
1.00 – 1.50	Very negative attitude Very lowly motivated Not understood

Note: A mean of 3.51 to 5.00 is an indication of a best teaching practice of a faculty that will lead to the attainment of interest in science and in learning science and understanding of the nature of science.

Practical Test. To measure the extent by which students manifest the attainment of the goals of science laboratory instruction in their laboratory skills, a Practical Test was constructed (See Appendix K). This Practical Test approximates not only the practical skills of the students but also their teamwork skills and understanding of the complexity and ambiguity of empirical work in a chemistry classroom. The instrument used in this test was a checklist which included items on common laboratory techniques such as handling liquids and measuring volume, handling solids and weighing, bunsen burner manipulation, heating substances in a test tube, doing evaporation, and doing filtration. It also included items that indicate if students consider safety precautions in performing experiments, if they exhibit teamwork skills and understand complexity and ambiguity of empirical work. Attached to the checklist was the list of materials and the procedure followed by the students in taking the Practical Test. The questionnaire was presented to the advisers for comments and suggestions. To ensure that the questionnaire was valid three chemistry experts were consulted for face and content validity.

The practical skills, teamwork skills, and the students' understanding of the complexity and ambiguity of empirical work was categorized and verbally interpreted as recommended by experts as:

Scale Range	Verbal Interpretation
76 % - 100 %	Highly competent / Highly understood
51 % - 75 %	Competent / Understood
26 % - 50 %	Moderately competent/Moderately Understood
0 – 25 %	Not competent / not understood

Note: A scale range of 51% to 100% is an indication that the faculty is implementing best teaching practices that will attain practical skills, teamwork skills and understanding complexity and ambiguity of empirical work.

Achievement Test. This was a Concept-Application-Procedural (CAP) Test developed to approximate whether the students had attain the mastery of subject matter and scientific reasoning (See Appendix M). Twenty one (21) items of this multiple choice test were categorized under mastery of subject matter while thirty eight items on scientific reasoning. Each question consisted of four options of which students encircled the correct answer. The questions were taken from the seven experiments performed during the semester such as Measurement; Changes in Matter; Classifications of Matter; Laws of Chemical Change; Types of Chemical Reactions; Solutions; and Classes of Compounds. Similarly, this questionnaire was subjected to face and content validity.The original 100 items were then reduced to fifty nine items after item analysis was done. The researcher also deleted the items which were not relevant to the topics. The data gathered by this instrument was interpreted using the following scale:

Scale Range	Verbal Interpretation
76 % - 100 %	high level of mastery / high level of scientific reasoning
51 % - 75 %	average level of mastery / average level of scientific reasoning
26 % - 50 %	low level of mastery / low level of scientific reasoning
0 – 25 %	no mastery / no scientific reasoning

Note: A scale range of 51% to 100% is an indication that the faculty is implementing the best teaching practices that will lead to attainment of mastery of subject matter and scientific reasoning.

Data Gathering Procedure

The study was conducted in successive phases. The details of activities can be referred to the Gantt Chart of Activities.

Phase I - Planning Stage. This stage involved the review of literature on the study and development of the instruments used in the study. A thorough reading of books, journals, theses and dissertations together with internet resources was made to gather theories and concepts related to best teaching practices. From the constructs gathered, five instruments were developed such as Focus Group Interview Questionnaire for Students and Faculty, Observation Checklist, Attitude/ Motivation Instrument, Practical Test and Achievement Test. The prepared instruments were presented to the advisers for comments and suggestions. To ensure that the instruments were valid, chemistry experts were consulted for face and content validity. Comments, suggestions and recommendations were considered to refine the instruments. It took the whole of the first semester to develop and validate the instruments. Phase I also entailed the securing of approval from Lyceum of the Phil. University in Batangas, Laguna, Cavite and Manila to conduct the study in their respective locuses.

Phase II - Gathering of Qualitative Data on Best Teaching Practices. This phase consisted of the focus group interview and class observations. Separate focus group interview for the faculty and students were conducted at the beginning of the second semester. Since the classes for the second semester started on the second week of November 2011, the focus group interview for faculty in the four universities was conducted on the last week of November of the same year. Focus group interview for students was conducted on the first week of December, 2011. Two to six chemistry faculty in each university were interviewed while a group of three to nine chemistry students were included in the focus group interview for the students. The students interviewed were the current students of the teachers who were observed for the study. The interview lasted for one hour. It was video-taped and the responses gathered were analyzed and interpreted qualitatively. The interview and focus group discussions were done to identify the teaching practices implemented by the faculty in order to attain the seven goals of science lab instruction.

To validate that the faculty was implementing the teaching practices that will attain the goals of science laboratory instruction, unannounced class observations were also conducted. Only one faculty per university was observed for this purpose. Class observation in each university was conducted for three different experiments performed by the class. Each observation lasted for three hours and was documented by photographs and video tapes. During the observation, the observable items from the instruction made by the faculty were checked. Each faculty got a score of one every time the item was observed and a perfect score of three if during the three observations made, the faculty always demonstrated such item. The faculty got zero if the item was never observed. The mean of the scores for each item of the four observed faculty was computed and was verbally interpreted according to the scale range recommended by experts. Class observation started on the second week of December 2011 and lasted until the last week of February 2012.

Phase III - Gathering of Quantitative Data on Best Teaching Practices. This phase consisted of determining whether the observed faculty implemented the goals of science laboratory instruction as manifested in the students' attitude, motivation, laboratory skills and achievement. The students were asked to answer Attitude/Motivation Test, did Practical Test and answered the Achievement Test at the end of the semester. The Practical Test was given on the first and second week of March 2012 while the Attitude/Motivation Test was administered together with the Achievement Test on the third week of March of the same year.

The Practical Test was conducted on the intact class of the observed faculty with the assistance of their teacher. The class was divided into groups and each group was given an allotted time of thirty minutes to finish the test including instructions on how they will do the test. Each student was given a copy of the procedure before the test. All materials such as laboratory equipments and reagents were made available already on the work table before the start of the test. During the test, the students were rated by checking the items which were observed from the group. The number of groups who demonstrated a particular skill was counted and the corresponding percentage out of the 18 groups of students was computed.

The Attitude/Motivation instrument was administered to the intact class of the observed faculty in each university at the end of the semester for a period of thirty minutes including instructions on how students will answer the instrument. For scoring purposes, a score of 5 was given if the respondent strongly agree to the item, 4 if agree, 3 if neither agree nor disagree, 2 if disagree and 1 if strongly disagree. The mean of the scores for each item of the 80 student respondents was computed and was verbally interpreted according to the scale range recommended by experts. The Achievement Test was administered to the intact class of the observed faculty at the end of the semester for a period of ninety minutes including the instructions on how students will answer the test. The perfect score for mastery of subject matter was 21 and for scientific reasoning was 38. The mean of the scores of the 80 student respondents and the corresponding percentage were computed and verbally interpreted according to the scale range recommended by experts.

Data Analysis Procedure

Content analysis of the responses of students and faculty in the FGI were done by deduction and induction. From here, it was determined whether the teaching practices implemented by the faculty conformed with the seven goals of science lab instruction.

To analyze the teaching practices observed among the faculty, the researcher made use of statistical mean. Frequency, percent, mean and standard deviation were used to describe the extent by which students manifest the attainment of the goals of science lab instruction in their attitude and motivation, lab skills and achievement. These statistical treatments were used to analyze the responses and performance of students in the Attitude/Motivation Test, Practical Test, and CAP test.

Results and Discussion

I. Teaching Practices Employed by the Faculty in Teaching Chemistry Laboratory in Order to Attain:

A. Mastery of Subject Matter

Table 1. *Practices Employed by Faculty in Designing their Laboratory Instruction*

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Basing on the syllabus; patterned with the sequencing of topics discussed in the lecture; making it simultaneous with the topic in the lecture; following the recipe-type of procedure

Students of LPU 1	Requiring students to do experiments which are similar to the topics discussed in the lecture; simply following the step-by-step procedure in the lab manual
Faculty of LPU 2	Doing experiments after discussing the concept in the lecture; performing experiments which are related and simultaneous with the topics discussed in the lecture; following the recipe type
Students of LPU 2	Discussing first the concept in the lecture and then applying it in the experiment; performing all the experiments related to the topics in the lecture; following the given procedures in the lab manual
Faculty of LPU 3	Performing experiments while discussion of the topics in the lecture is going on; designing it in a way that there's close supervision of students' learning simultaneously in lecture and lab; sometimes implementing discovery approach with investigative type of procedure
Students of LPU 3	Discussing the topic while performing experiment that is related to it; sometimes asking students to perform first the procedure given in the lab manual and then asking students what they learned from the result.
Faculty of LPU 4	Applying deductive approach; providing procedures in the laboratory manual; simply following the cook book style in the manual; doing experiments simultaneously with the discussed topics in lecture
Students of LPU 4	Requiring students to have individual laboratory manual; assigning students to read the experiment corresponding to the topic in the previous lecture before coming to class so that students can readily perform the written procedures while doing the experiment

Table 1 presents the practices employed by the faculty in designing their laboratory instruction. It shows that all of the four groups of faculty design their laboratory instruction in relation to the topics discussed in the lecture. They plan the science experiment according to how the topics in the classroom lectures were designed. Three out of the four groups make the experiment procedure in recipe type or cook book style, while only one group of faculty said that they sometimes implement the discovery approach where the procedures are following the investigative approach. They require their students to use laboratory manual where the list of experiments are conforming to the sequence of lecture topics indicated in the syllabus. One group of faculty discusses the topic during the lecture sessions of the class so that the students will be guided properly come laboratory periods.

All of the faculty-respondents plan the experiment to be done alongside the lectures because to them, the laboratory manuals were developed in relation to the topics discussed in the lecture. The presence of laboratory manuals, according to the teacher-respondents, allows them to follow the recipe type of experiment procedure. Some teachers are planning to shift to the investigative type, while some others are already implementing the discovery approach but still with close supervision of students. The group of faculty who are implementing the discovery approach are those with fewer students. As part of their strategy, the teachers conduct both lecture and laboratory classes in the laboratory room for the chance to add to the discussion while experiments are on-going. To them such style of handling laboratory instruction is aimed to have a close supervision of students' learning both in theory and in practice.

The data gathered indicate that the teachers relate laboratory activities closely with lectures in order to help students progress toward science learning goals. This conforms with the statement of the National Science Teachers Association (2005) that "laboratories and lectures are not separate activities." In the same scope, it also complies with the recommendation of the Committee on High School Laboratory to integrate laboratory experiences into instructional sequences (Singer, et al., 2005).

On the other hand, the reason for most of the teachers following the recipe-type of experiment procedure is because of lack of time to venture into investigative type of experiment. To the teacher-respondents, the pressure of trying to finish the syllabus for one semester marks the biggest hurdle for them. This finding is similar to the description of a typical science course given by Jona, et al. (2008) that students do not have enough time for planning investigation or interpreting results because teachers bombard them with so many lessons from the syllabus.

As reflected in the FGI with students, all the chemistry laboratory teachers from the four universities require their students to perform experiments in relation to the topics being discussed in their lecture. The lecturers are all following the given procedures included in their laboratory manual. Three out of the four groups of students have discussion of the concept in their lecture period prior to the performance of the experiment for their laboratory session. Only one group of students was required to perform experiment while the discussion of the topic is going on. In some cases, this same group of students sometimes perform the given procedure in their laboratory manual first before their teacher ask them on the learnings they get from the results of the experiment.

Still, table 1 indicates that most of the times teachers provide their students with prior knowledge of the concept of the experiment either by discussing it in the lecture before conducting the laboratory class or by assigning the students to read about the experiment before coming to the laboratory class. It could be that these teachers want that the learning gained by their students in the lecture could be retain longer through hands-on activities, or it could be that from the learning the students acquired in their lecture, the teacher can enable the students to reconstruct their previous knowledge by doing experiments.

These findings conform with Hidalgo's (2000) statement that in the laboratory method, "the learning gained by students is retained longer because the students are learning by doing."

Table 2 shows the practices of faculty in designing experiment if the necessary material and equipment is not enough for the entire class.

Table 2. ***Practices of Faculty in Designing the Experiment if the Necessary Material is Only Limited to One or Two Groups***

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Demonstration of experiment by the teacher; replacing materials; improvising instruments; not skipping any experiment in the manual for the reasons that instruments/materials are not available
Students of LPU 1	By rotation, by sharing, the teacher does not skip experiments when instruments/materials are not available; there is an alternative material/instrument for the unavailable one
Faculty of LPU 2	Not skipping experiment because materials and instruments are enough for the students
Students of LPU 2	The teacher divide the class two batches so that materials will be accommodated by all the students; unavailability of materials happen rarely; providing all materials/instruments so that no experiment is omitted
Faculty of LPU 3	Encouraging students to be resourceful; not skipping experiment due to unavailability of materials/instruments
Students of LPU 3	Does not happen that the materials /instruments are limited or not available because there are very few students in the class; doing all experiments in the lab manual
Faculty of LPU 4	Performing all experiments because all materials and instruments are available; delegating a representative student to demonstrate the procedure or sharing the materials to each group if the material is limited
Students of LPU 4	The teacher ask the most intelligent student to do the experiment in front of the class; the students are required to perform all the experiments in the lab

The table shows that all of the four groups of faculty do not skip experiments even though the instruments/materials needed are not available. Two groups of faculty do the experiment through demonstration of the procedure either by the teacher or by a representative student from the class. On the other hand, two other groups of faculty experienced having enough materials and instruments and are available to their students. One group of faculty pushed their students to be resourceful while one group improvised the unavailable instrument and replaced the unavailable or limited materials. Another group of faculty simply shared whatever material is available to the students.

All the faculty-respondents performed the experiments in the laboratory even if there is unavailability of instruments/materials because in their university the faculty themselves develop the laboratory manual so that all the needed instruments/materials were requested and were provided at the start of the semester. In case of limited number of equipment, the faculty concerned preferred to use the demonstration method of laboratory instruction to bridge the learning of students. This finding is similar to what Acero, et al. (2000) cited that demonstration method is an imitative method where learning a skill is faster and more effective if students are shown how the job is done by using the actual tools, machines and materials.

One of the results of the focus group interview, students point out that, the teachers require them to do all the experiments included in their laboratory manual and the unavailability of materials/instruments is not a reason for them to forego any experiment. If ever the necessary material is only limited to one or two groups, their teacher finds ways to address the problem. One group of students cited that if the materials/instruments are unavailable, their teacher makes the class to share the limited material or use the limited instrument by rotation. In their classrooms, there is always an alternative material/instrument for the unavailable one.

Another group of students pointed out that they rarely encounter unavailability of materials/instruments; if ever the material is limited, their teacher divides the class into two batches so that the limited material can be used by all members of the class. Another group of students pointed out that they never experienced limited or unavailable materials/instruments because they are very few in the class. On the other hand, the teacher of one group of students asks the most intelligent student among them to do the experiment in front of the class.

Table 2 also reveals that the teachers implement various techniques in handling problems such as unavailability or limited materials/instruments because these teachers have knowledge of the specific teaching strategies that can be used to address students' learning needs given particular classroom circumstances like lack of materials or equipment. These teachers do not skip experiments when materials/instruments are not available because they want to inculcate to their students the value of resourcefulness which is one of the scientific attitudes a student needs to develop. This is one of the forms of practical knowledge in the pedagogical content knowledge (PCK) of Shulman as cited by Rowan, et al. (2011).

The practices of the faculty on how they begin their laboratory class on the other hand, are presented in Table 3. The table shows that all the four groups of faculty begin their laboratory class by presenting the objectives of the experiment to their students. This is done when teachers state the goals and objectives of the experiment themselves or letting students read the objectives stated in the laboratory manual, or asking the students to think of more objectives aside from those stated in the laboratory manual.

Table 3. ***Practices of Faculty on How they Start their Laboratory Class***

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Giving a brief description of what the experiment is all about, how to do it, and what to expect from it; stating clearly the goal of the experiment
Students of LPU 1	Giving a brief summary of the experiment for the day is; the teacher states the objectives of the experiment; asking questions for students to discover the possible result of experiment
	Describing the procedure of the experiment;

Faculty of LPU 2	emphasizing the safety precautions; checking materials and lab gowns; letting students read the objective of the experiment since it is already in the manual
Students of LPU 2	The teacher introduces the experiment; making students read the manual since the objectives are already in the lab manual and then explaining the procedure
Faculty of LPU 3	Asking a series of questions so that students will begin thinking about the possible outcome of the experiment; telling the students the purpose of doing the experiment
Students of LPU 3	Allowing students to discover the outcome of the experiment; allowing students to expound on the objective of the experiment
Faculty of LPU 4	Reminding the students about laboratory policies such as proper arrangement of chairs and bags; asking students to think of more objectives of the experiment aside from those stated in the lab manual; asking students on how to apply the concept they learned from their lecture on the experiment
Students of LPU 4	Reviewing the topics discussed in the lecture and then asking students to relate it to experiment

Table 3 shows that two groups of faculty give descriptions of the procedure of the experiment to the students while two other groups remind the students on safety precautions and laboratory policies before any laboratory work is done. Two groups of faculty begin their laboratory class by asking questions to make students think of the possible outcome of the experiment or to let them connect the concept learned from their lecture to the experiment they will perform.

The responses of the faculty as shown in the table indicate that these teachers employ teaching practices which aim for the success of an experiment because they make their students understand the problem clearly before doing the experiment. This is in consonance to NSTA's (2007) description of a well- designed laboratory instruction where the objective of the activity is clearly communicated to students and gives opportunities to students to develop safe and conscientious laboratory habits and procedures.

As observed by the students, the teachers of the three groups of students clarify the objectives to the entire class at the beginning of the class. For the purpose of clarity, teachers of the two groups of students introduce the experiment or give a brief summary of the experiment. One group of students was allowed by their teacher to discover the outcome of the experiment on their own while one group of students was asked by their teacher to relate the topics discussed in their lecture to the experiment performed.

The data prove that the teachers implement a properly designed laboratory instruction because the students are allowed to expect outcomes or experimental results which may or may not be contradictory to the concept learned from their lecture. This conforms to one of the four principles of instructional design which according to NRC (2005) can help laboratory experiences achieve their intended learning goal. According to this principle, instructions must be design with clear learning outcomes in mind in order to attain the desired learning objective.

The practices of the faculty in conducting pre-lab discussion are shown in Table 4. It can be noted from the table that all the four groups of faculty list down vocabulary or terms related to the experiment, especially those important terms or concepts, the title of the experiment, materials needed, and even the set-up of the procedure is drawn on the board. Two groups of faculty use their students' prior knowledge and previous concepts learned as a basis for introducing new concepts. It is done by asking students of their ideas about the experiment before introducing it or by reviewing or recalling the previous concepts learned so that students can connect the gap between prior knowledge and the topic to be introduced while two groups of faculty allow their students to draw hypothesis about concepts by demonstrating selected procedures or by basing the hypothesis from their prior knowledge.

The responses of the faculty prove that they are implementing good practices in conducting pre-lab discussion because they provide a foundation of factual knowledge and conceptual understanding to students. It is responsive to the pedagogical practices identified by NRC (2005) which are considered authentic best practices in science teaching.

Table 4. ***Practices of Faculty in Conducting Pre-lab Discussion***

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Asking students of their ideas about the experiment before introducing it; writing important terms or concepts on the board
Students of LPU 1	The teacher stimulate the discussion by allowing students ask questions; allowing students to state their previous knowledge and are elaborated by the teacher; writing definitions of terms and keywords on the board
Faculty of LPU 2	Demonstrating selected procedures so that students can draw hypothesis from it; writing the title of the experiment and the materials needed on the board
Students of LPU 2	Demonstrating delicate procedures while the rest of the procedures are done by students at their own ; writing concepts on the board
Faculty of LPU 3	Writing vocabulary or terms related to the experiment on the board; asking students to formulate hypothesis about the experiment based on their prior knowledge

Students of LPU 3	Allowing students to make a guess on the result of the experiment before doing it by themselves; listing down vocabulary or terms related to the experiment on the board
Faculty of LPU 4	Reviewing or recalling the previous concepts learned to link previous topic to new topic or to have continuity of their previous knowledge; letting students connect the gap between prior knowledge and the topic to be introduced; writing meaning of terms on the experiment together with drawing of set-up on the board
Students of LPU 4	Asking students to recall and relate the concepts learned from the lecture to the experiment; drawing the set-up of apparatuses on the board

One of these authentic best practices is engaging resilient preconceptions where teachers identify, confront and resolve this initial understanding of the students. Another authentic best practice is organizing knowledge around core concepts which aims to increase understanding and retention of concepts among students.

Cited in the responses of students, the teachers of the four groups of students conduct their pre-lab discussion by first writing on the board the keywords, definitions of terms, concepts and set-up of the apparatuses to be used in their experiment. Two groups of students were asked to recall and state their previous knowledge before the conduct of the experiment. The teacher of one group of students demonstrates the varied procedures of their experiment while one group was asked by their teacher to infer on the result of the experiment before doing the actual experiment.

The data revealed that the teachers practice a properly designed pre-lab discussion because they help students move towards a more scientific understanding of what students understand about the prior concepts they learned. This finding affirms Singer's, et al. (2005) idea of an integrated instructional units which she believes is an effective instruction because it begins with what learners bring to the setting such as knowledge of academic content.

The practices of the faculty-respondents in supervising or guiding students in the process of performing the experiment are shown in Table 5. From the table, it is clear that all of the four groups of faculty supervise and guide their students in the process of performing the experiment by moving around the laboratory room to check if each group of students does the experiment properly. Two groups of faculty never allow their students to manipulate the procedures and materials while one group of faculty allows students to manipulate the procedure and materials if they have their approval. Another group of faculty allows their students to manipulate procedures and materials depending on the situation such as when materials are not available so that the students are allowed to use replacement.

Table 5. ***Practices of Faculty in Supervising or Guiding Students in the Process of Performing Experiment***

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Moving around the room, checking each group if they follow the correct procedure; entertaining questions from students; not allowing students to manipulate procedures and materials
Students of LPU 1	Asking questions upon seeing that students are not following the procedure correctly; roaming around the room; entertaining questions; consent is being asked from the teacher if students want to manipulate procedure or materials
Faculty of LPU 2	Going from one group of students to another group; seeing if they are doing the experiment properly; never allowing students to manipulate procedures and materials
Students of LPU 2	The teacher is moving around and checking each group if they are doing the experiment correctly; not allowing any manipulation of procedure or materials
Faculty of LPU 3	Going around and checking each group as to how they do the experiment; not allowing students to manipulate the procedure and the materials without their approval
Students of LPU 3	Moving around; not allowing students to do manipulation of procedure nor materials
Faculty of LPU 4	Making rounds; discussing with each group one at a time; allowing students to manipulate procedures and materials depending on the situation; using replacement if materials are not available
Students of LPU 4	Going from one group to another finding out if students are having problem with the experiment; allowing students to improvised unavailable instrument or use substitute materials

Based on the responses presented, it seems that these teachers employ the method of small group instruction by moving from one group to another because they want to give attention to each students' learning needs. This is in response to Hidalgo's (2000) idea of small group instruction where students become more actively involved in their own learning and participate more freely in discussions.

As observed by students, the teachers of the four groups of students supervise students in doing experiment by moving around the room to check whether each group is doing the procedure properly. Two out of the four groups of students are not allowed to manipulate procedure or materials, while one group ask consent from their teacher when they want to do some manipulations. Only one group of students was allowed to improvised instrument or use substitute materials.

Most of the practices of faculty, observed by the students, reveal that they make close supervision of the students while doing experiment because of the high demand for success. This is in consonance to what Salandanan (2002) emphasized when she said that for an experiment to be successful, the teacher must be a keen observant who can easily spot incorrect steps and procedure. Table 6 shows the practices of faculty in conducting a post –lab discussion.

Table 6. ***Practices of Faculty in Conducting a Post-lab Discussion***

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Asking the students to relate the result of the experiment to their previous discussion; giving the positive result which may or may not be contrary to the result obtained by students; allowing students to compare their results to find out their mistakes; giving post-lab quiz in the next lab period
Students of LPU 1	Discussing partial result before the expt; discussing the result of experiment after the expt if there's enough time; giving correct result; allowing students to compare result; giving post- lab quiz the following meeting
Faculty of LPU 2	Calling all members of the group to discuss their result; discussing only questions in the manuals; allowing students to compare results per procedure with each group; giving post-lab quiz the following meeting
Students of LPU 2	Asking students about their ideas on the result of the expt; allowing students compare ideas; telling which is the correct result
Faculty of LPU 3	Conducting post-lab discussion during lecture time; requiring students to report the result; allowing students to compare results but not letting them change their result; giving post-lab quiz during lecture
Students of LPU 3	Allowing students to compare results with other groups and if there are discrepancies making students retest or repeat the procedure; giving post-lab quiz during lecture time
	Conducting a post-lab discussion a meeting after;

Faculty of LPU 4	providing more questions to students if the result deviate from expected result; allowing students to compare results to identify why they are wrong and how they can correct their mistakes; giving post-lab quiz after post-lab discussion
Students of LPU 4	Allowing comparison of result to know their mistakes; giving quiz after discussion of result

All of the four groups of faculty require their students to do the discussion by asking them to relate the result to their previous discussion, by reporting, or by providing more questions for students to answer. All of them allowed their students to compare result with other groups of students and all of them give a post –lab quiz after the post-lab discussion.

It is reflected in the table that the teacher-respondents conduct post- lab discussions to clarify the results in relation to the lecture. They require their students to do the discussion with the aim of teaching their students communicative skills. This is similar to the laboratory principle identified by Kanli and Yagbasan (2008) which states that teachers must encourage students to explain by demanding proofs or making students use the data they acquired in making reasonable explanations.

As observed by students, all the four groups of students were allowed by their teachers to compare the results of experiment with those of their classmates. Three groups of students were given a post-lab quiz after the post-lab discussion. Only two groups were given the correct result of the experiment by their teacher while the other two groups of students were allowed by their teacher to find their own mistakes.

It is also evident from the table that the teachers conduct a post-lab discussion in order to provide the necessary connection between the result of the experiment and the appropriate science concepts. Students were allowed to compare results with their classmates so that they can identify and correct their own mistakes. This conforms with Piaget's Theory of Constructivism where children are allowed to make mistakes and correct these on their own thereby enabling them to accommodate, assimilate and reconstruct knowledge on their own (Muijs and Reynolds, 2011). Table 7 presents the data gathered from class observations to determine

Table 7. *Practices Observed Among the Faculty that will Enhance the Mastery of Subject Matter*

Practices	Mean	Verbal Interpretation
1. Giving a brief description of the experiment for the day	3.00	Always
2. Stating the goals and objectives of the experiment	3.00	Always
3. Letting the students think of the objectives in	0	Never

doing the experiment		
4. Asking a series of questions for the students to begin thinking about the topic	2.75	Always
5. Presenting challenging questions to draw out the preconceptions of the students	2.00	Often
6. Conducting a pre-lab discussion	3.00	Always
7. Using the students' prior knowledge as a basis for introducing new concepts	2.75	Always
8. Allowing the students make observations and draw conclusion about concepts prior to giving explicit instruction	2.50	Always
9. Listing down vocabulary or terms related to the experiment	3.00	Always
10. Supervising/guiding the students in the process of performing the experiment	3.00	Always
11. Allowing the students explore ideas rather than manipulate material and procedures	1.00	Sometimes
12. Making the experiment procedure in recipe type	3.00	Always
13. Making the experiment procedure in an open-ended or investigative type	0	Never
14. Conducting a post-lab discussion	3.00	Always
15. Discussing the results of the experiment in relation to lecture content	3.00	Always
16. Administering a post-lab quiz right after the experiment	1.50	Sometimes
17. Providing guide questions for students to answer	3.00	Always
18. Allowing students to compare results with other groups and making sense of the collective data of the class		
19. Providing the necessary connection with the results of the experiment and the appropriate	2.75	Always
science concepts	3.00	Always
OVERALL MEAN	2.38	ALWAYS

The practices implemented by the faculty in enhancing mastery of subject matter. The data reveal that teachers always implement the given practices with a mean of 3.00. Practices like giving a brief description of the experiment for the day, stating the goals and objectives of the experiment, conducting a pre-lab discussion, listing down vocabulary or terms related to the experiment, supervising/guiding the students in the process of performing the experiment, making the experiment procedure in a recipe type, conducting a post-lab discussion, discussing the results of the experiment in relation to lecture content, providing guide questions for students to answer and providing the necessary connection with the results of the experiment and the appropriate science concepts are marked as common practices among the teacher-respondents.

Practices with a mean of 2.75 on the other hand, are always implemented by the teachers. These practices are asking a series of questions for the students to begin thinking about the topic, using the students' prior knowledge as a basis for introducing new concepts, and allowing students to compare results with other groups and making sense of the collective data of the class. The teachers sometimes implement those practices with a mean of 1.50 and 1.00. These are administering a post-lab quiz right after the experiment and allowing students to explore ideas rather than manipulating materials and procedures. Practices with a mean of 0 and a standard deviation of 0 are never implemented by the teachers. These are letting the students think of the objectives in doing the experiment and making the experiment procedure in an open-ended or investigative type.

In general, the overall mean of 2.38 was an indication that the teachers always implement practices that enhance the mastery of subject matter among students. It could mean that these teachers exert efforts in teaching the content and process as related educational goals because they want their students to readily understand and apply the concept they acquired. This finding is similar to what Jona, et al. (2008) stated that mastery of subject matter could be attained if concepts and processes are taught simultaneously so that students perform a process with a clear understanding of the relation of that process to content.

B. Scientific Reasoning

The practices employed by faculty in developing scientific reasoning among their students are revealed in Table 8. The table reveals that all the four groups of faculty require scientific explanations for the result of experiment. Two groups of faculty give on-the-spot questions while performing experiment. One group of faculty require students to submit a reflection paper while the other group of faculty allow their students to reflect by sharing with other students what they have learned from the experiment. One group of faculty let their students check their data, analyze and repeat the procedure when they got a wrong result while another group of faculty ask their students to trace all the errors.

It appears from the table that the teachers implement practices that develop scientific reasoning of students because they require students to make scientific explanations of the occurrence of events as in the result of the experiment. They teach their students valid reasoning principles and at the same time give opportunities to their students to practice these reasoning skills. This is in consonance with the integrated learning program of NRC (2005) which is considered an effective instructional practice because students can relate theoretical claims with evidences gathered from laboratory investigation.

Table 8 presents the practices of faculty in developing scientific reasoning among students. As observed by students, all the teachers of the four groups of students require them to analyze and explain the data, their observations and discuss the results of the laboratory activity. Two groups of students are given on- the- spot questions asking them the reason for doing such procedure. Two groups of students are asked to do error analysis and to find out the sources of error while two groups of students are required to submit reflective essay or narrative reflection of what they learned.

The practices of the faculty as observed by the students revealed that their teachers implement practices that develop scientific reasoning among them because they were taught how to explain and give reasons for what they are doing. Some of their teachers allow them to reflect on their own learning so that these teachers practice metacognitive strategies. Metacognitive strategies according to Singer, et al. (2005) when implemented in a knowledge-centered environment will enable students to reflect on their own learning progress, to identify, monitor and regulate their own thinking and learning which in turn will facilitate their learning.

Table 8.
Practices of Faculty in Developing Scientific Reasoning Among Students

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Allowing students to develop scientific explanations for the result of the experiment; asking on-the-spot questions while performing experiment; asking students to defend why they got such a result; requiring students to submit a reflection paper on what they learned
Students of LPU 1	Asking students why they are doing such procedure and what they observe; asking the class to explain how they arrived to the result; requiring students to pass a reflective essay for the whole semester
Faculty of LPU 2	Giving on-the-spot questions while doing the experiment to check if they are following procedure correctly; asking only those who are not following correct procedure; tracing all the errors before allowing students to develop their scientific explanation
Students of LPU 2	Asking students to do error analysis; asking students to explain and analyze the data obtained; on-the-spot questions are addressed to the idle member of the group
Faculty of LPU 3	Asking the students to explain why they were not able to produce the result; letting students check their data, analyze and repeat the procedure
Students of LPU 3	Requiring students to analyze and explain the data and graphs obtained and to discuss the results; asking students to find out the sources of error

Faculty of LPU 4	Making students defend their result based on the laws and principles studied; allowing students to make reflection by sharing with other groups what they learned from the experiment
Students of LPU 4	Asking students to submit a report sheet for every experiment which is a narrative reflection of what students learned from the experiment; asking students to discuss the observations

In addition to this, Kanli and Yagbasan (2008) said that teachers must demand explanations and proofs from students and at the same time emphasize that students should use the data they acquired to make reasonable explanations.

Table 9 presents the data gathered from class observations to determine the practices employed by the faculty in their instruction to develop scientific reasoning among their students.

Table 9. ***Practices Observed among the Faculty that will Develop Scientific Reasoning of Students***

Laboratory Practices	**Mean**	**Verbal Interpretation**
1. Encouraging the students to design and conduct scientific investigations	0.25	Never
2. Requiring students to identify questions and concepts that guide scientific investigation	0.25	Never
3. Giving on-the-spot questions to check the understanding of students of why they are doing such procedure	3.00	Always
4. Allowing students to develop and revise scientific explanations and models or recognize and analyze alternative explanations and models	0.50	Never
5. Allowing students make and defend a scientific argument by reviewing information, using scientific language appropriately, constructing a reasoned argument, and responding to critical comments	0.75	Never
6. Requiring students to explain/analyze their data, discuss the results including graphs and do error analysis	3.00	Always
7. Requiring students to make reflection where	0.50	Never

they will defend their conclusions based on data and analysis of data, compare results with other sources and explain differences		
OVERALL MEAN	1.18	Sometimes

As shown in the table, the practices such as giving on- the-spot questions to check on the understanding of the students of why they are doing such procedure, and requiring students to explain/analyze their data, discuss the results including graphs and do error analysis received a mean of 3.00 which shows that the teachers always practice them. Allowing students to make and defend a scientific argument by reviewing information, using scientific language appropriately, constructing a reasoned argument, and responding to critical comments got a mean of 0.75 indicating that it is never implemented by the faculty. Practices with a mean of 0.50 and 0.25 are never implemented by the faculty. These refer to allowing students to develop and revise scientific explanations and models and recognize and analyze alternative explanations and models; requiring students to make reflection where they will defend their conclusions based on data and analysis of data, compare results with other sources and explain differences; encouraging students to design and conduct scientific investigations; and requiring students to identify questions and concepts that guide scientific investigation.

In general, the overall mean of 1.18 was an indication that the teachers sometimes implement practices that develop scientific reasoning of their students. It could mean that these teachers cannot employ the inquiry method of laboratory instruction which allow their students to make their own investigation because they lack enough time to conduct such investigation since they are pressured to finish the syllabus before the end of the semester. This is contrary to the idea of Salandanan (2002) that "in the inquiry approach, the reasoning skills of the students are improved upon learning how to investigate and discover new information."

C. Understanding Complexity and Ambiguity of Empirical Work

Table 10 shows the practices of faculty in developing the students' understanding of the complexity and ambiguity of empirical work. Two groups of faculty avoid errors due to equipment failure by allowing the technician do the checking and troubleshooting of equipment before an experiment, whereas only one group of faculty teach students how to troubleshoot equipment.

Table 10. *Practices of Faculty in Developing Students' Understanding ofComplexity and Ambiguity of Empirical Work*

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Explaining the cause of error; teaching students in troubleshooting equipments in order to avoid errors; asking students to make several trials to check precision and accuracy

Students of LPU 1	Teaching students on the maintenance and proper care of equipments; requiring students to repeat the procedure if the data is not precise or accurate; explaining that errors cannot be avoided
Faculty of LPU 2	Asking the technician to do the calibration and troubleshooting of equipments; giving hints to students to account for discrepancies like for example in the unit conversion
Students of LPU 2	Replacing equipments which are not functioning; giving the students clues when there are deviations from expected values
Faculty of LPU 3	Checking the equipment before using; doing a dry-run of the experiment before asking students to perform; letting students compare their data with the standard
Students of LPU 3	Making alternative equipments available if there is malfunctioning of equipments; giving already the expected value before the experiment
Faculty of LPU 4	Explaining to students that there are conditions which may affect the result; asking the technician to check the equipments before lending to students and do the troubleshooting of malfunctioning equipments; requiring students to make three trials for every measurement
Students of LPU 4	Asking the students to replace the malfunctioning equipments; explaining the factors which may cause error

The table also shows that two groups of faculty explain the cause of error and clarified that there are conditions which may affect the result. Two groups of faculty require their students to make several trials in order to check for precision and accuracy of data while only one group of faculty gives hints to students to account for discrepancies. Still another group of faculty allows students compare their data with the standard.

The data indicate that the faculty design their laboratory instruction in such a way that students are able to expect outcomes or experimental results which are contradictory to the accepted scientific principle. This conforms to Jona, et al. (2008) statement that experimental errors are not hindrances to learning, but they are opportunities for greater learning. So instead of working hard to remove complexities and ambiguities, laboratory instructors should include the expectation of experimental errors in their instruction.

As observed by students, the teachers of the three groups of students replace the malfunctioning equipment while only one group of students were taught how to maintain and give proper care to equipment. The teacher of one group of students explains that errors cannot be avoided while the teacher of another group explains the factors which may cause errors. One group of student said that they are given the expected value before doing the experiment while another group said that they are required to repeat the procedure if the data is not precise or accurate and still another group said that their teacher give clues when there are deviations from expected values.

The data confirm that the teachers implement practices which enable the students to find solutions to problems encountered while performing experiments. They make their students understand that even the same experiment may lead to different results if performed at different times or by different people. According to NRC (2005), a well designed scientific investigation program must include opportunities for students to be involved in activities like rechecking data observations and analysis and performing the kind of follow-up investigations that will validate the result of the investigation.

The teaching practices observed among faculty to attain the understanding of complexity and ambiguity of empirical work of students are shown in Table 11. Teaching practices with a mean of 2.75 and 2.50 show that they are always implemented by the faculty-respondents. These practices are giving some clues to students to account for the discrepancy; making the students take notice of serious experimental errors due to equipment failure; emphasizing the need to compare data from standards or controls; making students take notice of precision issues and accuracy issues where accuracy depends on the standardized calibration; and letting students notice deviations from expected values.

The faculty-respondents often implement those practices that got a mean of 2.25 and 2.00. These practices are helping students learn to address the challenges inherent in directly observing and manipulating the material world, including troubleshooting equipments used to make observations, understanding measurement error, and interpreting and aggregating the resulting data; emphasizing to students that random error is a normal part of the data and the data must have random error that cannot be eliminated through careful data collection; and allowing students to check repeatability of data they gathered.

Table 11. ***Practices Observed among the Faculty to Develop the Students' Understanding of Complexity and Ambiguity of Empirical Work***

Laboratory Practices	Mean	Verbal Interpretation
1. Helping students learn to address the challenges inherent in directly observing and manipulating the material world, including troubleshooting equipment used to make observations, understanding measurement error, and interpreting and aggregating the	2.25	Often

resulting data		
2. Making students take notice of precision issues and accuracy issues where accuracy depends on the standardized calibration	2.50	Always
3. Emphasizing to students that random error is a normal part of the data and data must have random error that cannot be eliminated through careful data collection	2.00	Often
4. Giving some clues to students to account for the discrepancy	2.75	Always
5. Making the students take notice of serious experimental errors due to equipment failure	2.75	Always
6. Letting students notice deviations from expected values	2.50	Always
7. Allowing students to check repeatability of data they gathered	2.00	Often
8. Emphasizing the need to compare data from standards or controls	2.75	Always
OVERALL MEAN	2.44	Always

The overall mean of 2.44 was an indication that the teachers always implement practices that will attain the understanding of the complexity and ambiguity of empirical work of students. This shows that the teachers help their students find solutions to problems encountered while performing experiments because they have the pedagogical content knowledge which according to Shulman's view as cited by Rowan, et al. (2011) is the knowledge of a teacher of the difficulties that students encounter when learning particular content.

D. Practical Skills

Table 12 shows the practices of faculty in developing the practical skills of students. All the four groups of faculty teach their students on the proper use of laboratory equipment and then check if they acquired the skills on its use by means of practical tests. All of them are particular with safety precautions such as the use of laboratory gowns. Two groups of faculty check the data and observations recorded by their students. Two groups of faculty check whether their students read the procedure before coming to class by giving a pre-lab quiz or by looking at the amount of reagents they are getting and the sequence of steps they are following.

From their practices, it is clear that the faculty implement teaching practices which develop the practical skills of their students because they are concerned not only with the proper use of equipments but also with the safety of the students in following correct procedure. With this concern, students can apply effectively the appropriate practical skills acquired to a new investigation similar to the inquiry-based laboratory investigation recommended by NSTA (2007) where students learn appropriate laboratory techniques to define and solve problems.

Table 12. *Practices of Faculty in Developing Practical Skills of Students*

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Training students on the proper use of lab equipments such as measuring devices; checking whether students are recording their observations correctly; checking the use of lab gowns and reminding of other safety precautions
Students of LPU 1	Explaining to students the use of an instrument demonstrating how it is used and its proper care and maintenance; putting deductions on those who are not wearing lab gowns
Faculty of LPU 2	Demonstrating to students the proper operation of lab equipments per group; checking the data of students in their manual; checking whether they read the procedure before the experiment by looking at the amount or reagents they are getting and the sequence of steps they are following; constantly reminding them of safety precautions
Students of LPU 2	Explaining the procedure at the same time teaching students how to use the equipment; checking whether students acquire the skill in using equipment during practical exams; implements wearing of lab gown is a must; moving around to check the data recorded in the manual
Faculty of LPU 3	Giving precautionary measures for every experiment; giving practical test to determine if students learned the skills in using lab equipment
Students of LPU 3	Emphasizing the precautions written on the manual and the use of lab gowns; checking the data sheet to find out if students got the correct observation; teaching students the proper use of equipments
Faculty of LPU 4	Giving practical exam; giving a pre-lab quiz to determine whether they read the procedure before coming to class; not accepting students if they are not in their lab gown
Students of LPU 4	Not allowing students enter the lab room if not in lab gown; keep on saying "As long as you handle reagents and instruments properly, no accident will happen"

As observed by students, all the teachers of the four groups of students require their students to wear laboratory gowns. Three groups of students are taught by their teachers on the proper use of laboratory equipment. The teachers of two groups of students check their data while the teacher of one group of students check their skill in using equipment during practical exams.

Most of the practices of faculty, as observed by students, indicate that the teacher is concerned with the safety of the students in doing experiment like wearing of laboratory gown because for them this is one of the skills they must learn in chemistry. This conforms with the belief of NSTA (2007) that laboratory investigation is well-designed if it gives opportunities to students develop safe and conscientious laboratory habits and procedures.

The teaching practices observed among the faculty to develop the practical skills of students are shown in Table 13. As indicated in the table, the faculty always implement the practices with a mean of 3.00. These practices are requiring students to read and understand procedures before carrying them out and adapt them as required; checking whether students know how to operate laboratory equipment and understanding exactly how equipment works before physically approaching it; reminding the class about safety precautions and checking whether the students observe the precautions; helping students develop skills in using scientific equipment correctly and safely, making observations, taking measurements, and carrying out well-defined scientific procedures; requiring students make and record observations of their experiment; teaching the students to use measurement devices and to record data with correct precision; and checking the student response to in the lab report data table for correct accuracy and precision.

Table 13. *Practices Observed among the Faculty to Develop Practical Skills of Students*

Laboratory Practices	Mean	Verbal Interpretation
1. Requiring students to read and understand procedures before carrying them out and adapt them as required	3.00	Always
2. Providing the students with hints and suggestions on possible experimental design and encouraged students to try their own ideas	0.25	Never
3. Checking whether students know how to operate laboratory equipment and understanding exactly how equipment works before physically approaching it	3.00	Always
4. Reminding the class about safety precautions and checking whether the students observe the precautions	3.00	Always
5. Allowing students to visually describe the procedures of the experiment before actually doing it	2.25	Often

6. Helping students develop skills in using scientific equipment correctly and safely, making observations, taking measurements, and carrying out well-defined scientific procedures	3.00	Always
7. Requiring students make and record observations of their experiments	3.00	Always
8. Teaching the students to use measurement devices and to record data with correct precision	3.00	Always
9. Providing opportunities for students to take readings from equipments	2.75	Always
10. Checking the student response in the lab report data table for correct accuracy and precision	3.00	Always
11. Encouraging students to deviate from given procedures if they know what they are doing	0.25	Never
12. Encouraging students to consider alternative procedures and providing them with sufficient instructions to succeed	0	Never
13. Checking whether students really acquired the necessary skills in the experiment	2.75	Always
OVERALL MEAN	2.25	Often

Similarly, providing opportunities for students to take readings from equipment and checking whether students really acquired the necessary skills in the experiment, are also implemented always by the faculty because they got a mean of 2.75. Allowing students to visually describe the procedures of the experiment before actually doing it got a mean of 2.25 which means that this is often implemented by the faculty. However, practices with a mean of 0.25 and 0 are never implemented by the faculty. These practices are providing the students with hints and suggestions on possible experimental design and encouraged students to try their own ideas; encouraging students to deviate from given procedures if they know what they are doing; and encouraging students to consider alternative procedures and provide them with sufficient instructions to succeed.

In general, the overall mean of 2.25 was an indication that the teachers often implement practices that develop the practical skills of their students. It reflects that they are doing these practices because they believe that with those teaching practices they can enhance the skills of students in employing a systematic and scientific methodology which in turn according to Salandanan (2002) will enable their students "to experience step-by-step procedure in finding answers to their endless questions." This is supported by Moni's, et al. (2007) statement that "teachers must teach skills to students with the expectation that competencies in skills would support open-ended, student-driven explorations."

E. Understanding the Nature of Science

Table 14 presents the practices of the faculty in developing students' understanding of the nature of science.

Table 14. *Practices of Faculty in Developing Students' Understanding of the Nature of Science*

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Telling the students that their previous knowledge may or may not affect their conclusion; helping students to overcome errors by following procedures correctly; allowing students to interpret their data based on their own understanding
Students of LPU 1	asking student's own interpretation of the data, however at the end she will give the actual interpretation by relating it to the theory; explaining the source of error and then giving students another chance to correct their error; correcting students' misconceptions
Faculty of LPU 2	Asking students at the start of the experiment to give their knowledge about the concept and telling them that their knowledge may or may not affect their conclusion; giving tips to students on how to overcome errors
Students of LPU 2	Advising students to overcome error; asking students about their ideas, then compare our ideas and she will be the one to tell which is correct
Faculty of LPU 3	Gathering preconceptions of students before the experiment; making explanations if after the experiment the result is contradictory to their preconception; telling students that errors are normally encountered but it can be overcome
Students of LPU 3	Asking students to trace the cause of error so that next time they can avoid it; always tell the students that they cannot simply rely on what they previously know, they have to discover more
Faculty of LPU 4	Emphasizing to students that their ideas might be pure misconceptions; telling students that errors may be overcome only by correct techniques
Students of LPU 4	Often telling students that different persons have different interpretation of the result but whatever the interpretation is, it depend on their previous understanding of the concept

All the four groups of faculty advise their students to overcome their errors and also emphasizing to their students that each person's preconceptions or prior knowledge may or may not affect the final conclusion. Only one group of faculty allow their students to interpret their data based on their own understanding.

The practices of the faculty indicate that the teachers are implementing practices that make students understand that science is a way of knowing aside from being a human endeavour. It is a way of knowing because the prior knowledge the students have may or may not be contrary to the result of their experiment. If the prior knowledge is a misconception then the teacher must find ways to correct it, however if the previous knowledge conforms with the result of the experiment, then the teacher must give opportunities to student to construct or build new ideas. This conforms well with Piaget's Theory of Constructivism (Muijs and Reynolds, 2011) which states that knowledge is always a construction by the learner where the student actively construct new concepts based upon prior knowledge and new information. On the same level, this reflects Singer's, et al. (2005) statement that "teachers must be challenged with the intuitive ideas of students by helping them move towards a more scientific understanding through change in and not merely an addition to what students notice and understand about the world."

To the students, the teachers of the three groups of students advised them to overcome error, to trace the cause or source of error and to correct their error. Two groups of students were asked by their teacher to make their own interpretation of the data or result of the experiment and telling that different persons have different interpretation. The teacher of one group of students corrects the previous knowledge of students if it is a misconception, another group of students were asked to discover more and not simply rely on their previous knowledge, while the teacher of another group of students tells the students that their interpretation depends on their previous knowledge.

The data showed that the teachers design laboratory instruction that develop the students understanding of the nature of science because they are trying to emphasize that knowledge is subject to change. This supports Crowther's, et al. (2005) suggestion to teachers to design lessons around science topics or concepts that have changed over time and the instruction must be explicit on how knowledge has changed and why.

Table 15 presents the practices observed among the faculty to develop the students' understanding of the nature of science. As shown in the table, the faculty always emphasize to the students that each person's preconceptions may or may not affect the final conclusion. It has a mean of 2.75. They often allow the students discover that different people may interpret the same data differently. This got a mean of 1.75. Advising the students to help them overcome errors, and discover that science is not as simple or as "black and white" as they may have thought got a mean of 1.75. This is also often implemented by the faculty.

Table 15. ***Practices Observed Among the Faculty to Develop Students' Understanding of the Nature of Science***

Laboratory Practices	Mean	Verbal

		Interpretation
1. Allowing the students discover that different people may interpret the same data differently	1.75	Often
2. Emphasizing to the students that each person's preconceptions may or may not affect the final conclusion	2.75	Always
3. Advising the students to help them overcome their errors, and discover that science is not as simple or as "black and white" as they may have thought	1.75	Often
OVERALL MEAN	2.08	Often

As a general picture, the overall mean of 2.08 was an indication that the teachers often implement practices that develop the students' understanding of the nature of science. It could reflect that these teachers want to emphasize in their instruction that knowledge is subject to change because of the different types of investigations that provide different information and evidence concerning the natural world. Crowther, et al. (2005) reflect the same argument when he said that "scientific knowledge in and of itself is not static and that with new information, scientific theories can change."

F. Interest in Science and Interest in Learning Science

The practices of the faculty in cultivating students' interest in science and interest in learning science are shown in Table 16.

Table 16. *Practices of Faculty in Cultivating Students' Interest in Science and Interest in Learning Science*

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Making students realize how important their lesson is to their daily life situations; challenging them to find out for themselves the possible result if a certain situation may happen
Students of LPU 1	Asking students to relate the experiment to real life situation; at the end of our lesson, the teacher often leaves a question for the student to answer
Faculty of LPU 2	By emphasizing the relevance of what they are studying to their future job; by showing some magic in chemistry

	during pre-lab discussion
Students of LPU 2	Often telling us stories on how she apply the knowledge in chemistry in her on-the-job training; the teacher trigger students' interest in the topic at the start of the lesson
Faculty of LPU 3	Telling simple jokes about chemistry to motivate students; conducting plant visits to chemical industries
Students of LPU 3	making the lesson not boring by telling funny stories about chemistry; taking students on field trips
Faculty of LPU 4	Stating the relevance of the lesson; connecting the lesson to real world experiences
Students of LPU 4	Asking students to give practical applications of what they learned in chemistry

All of the four groups of faculty provide practical and real life situations where the experiment is applicable by making students realize how important their lesson is to their daily life situation, emphasizing the relevance of what they are studying to their future job, conducting plant visits to chemical industries, stating the relevance of the lesson and connecting the lesson to real world experiences. Two out of the four groups of faculty motivate their students at the beginning of the lesson by showing some magic in chemistry and telling simple jokes about chemistry. Only one group of faculty said that they challenged their students to find out for themselves the possible result if a certain situation happens.

The practices of the faculty proved that these teachers have a great desire to develop positive attitudes among their students towards chemistry and make them highly motivated to continue learning chemistry. Positive attitude is developed if a student is highly motivated and this can be done by the teacher through improving the teaching practices and by showing to the students the relevance of the topic to their everyday lives. This finding is similar with that of Movahedzadeh's (2011) findings that students lose interest in science when the teaching of its context seems irrelevant to their lives or even to their future jobs.

As observed by students, the teachers of the four groups of students emphasize the application of their learning in chemistry by asking them to relate the experiment to real life situation, telling stories on its application to on-the-job training, going on field trips, asking them to give its practical applications. The teachers of two groups of students motivate them or trigger their interest in the topic at the beginning of the lesson and make their lesson not boring by telling funny stories about chemistry. The teacher of one group of students often leaves a question for the student to answer.

The table clearly shows that the teachers engage themselves in a more interesting approach that will make the students see the value of chemistry and will motivate them to develop a positive attitude towards the subject. The practices implemented by the teachers are in conformity to the teaching principle of Kanli and Yagbasan (2008) of exciting students by making a spark about the subject.

The practices observed among the faculty that will cultivate students' interest in science and interest in learning science are presented in Table 17.

Table 17. ***Practices Observed Among the Faculty to Cultivate Students'Interest in Science and Interest in Learning Science***

Laboratory Practices	**Mean**	**Verbal Interpretation**
1. Providing avenue where interest of students are triggered making them more eager to find out the answer through experimentation	2.50	Always
2. Illustrating how "alive" science can become if lab experiences are not limited to routine classroom laboratory	1.75	Often
3. Providing practical and real life situations where the experimental set-up is applicable	2.50	Always
4. Providing thought-provoking questions that compels students to find out things by themselves	2.00	Often
OVERALL MEAN	2.19	Often

As shown in the table, the teachers always implement practices such as providing avenue where interest of students are triggered making them more eager to find out the answer through experimentation and providing practical and real life situations where the experimental set-up is applicable. These practices got a mean of 2.50. Practices with a mean of 2.00 and 1.75 are often implemented by the faculty: providing thought-provoking questions that compel students to find out things by themselves; and illustrating how "alive" science can become if lab experiences are not limited to routine classroom laboratory.

In general, the overall mean of 2.19 was an indication that the teachers often implement practices to cultivate the interest of students in science and their interest in learning science. It could be generalized that these teachers are committed to their desire of creating a learning environment that will encourage and inspire students to have a desire to learn and enjoy learning. These teachers have a vision in mind of making their students become future scientist who will contribute to the progress of the nation, similar to what Salandanan (2002) had said. According to her, with high motivations, students will decide to pursue a science profession in the future and will develop a feeling of gratitude and appreciation for the advances in science and technology that continue to raise the present quality of life.

G. Teamwork Skills

The practices of the faculty in developing teamwork skills among students are presented in Table 18.

Table 18. *Practices of Faculty in Developing Teamwork Skills of Students*

Group of Respondents	Laboratory Practices of Faculty
Faculty of LPU 1	Grouping students alphabetically; grouping is permanent throughout the entire semester; assigning of leader in a group who is responsible for dividing the task among members; rotational leadership is implemented
Students of LPU 1	Grouping the class into 5 members each; assigning a different group leader for every experiment; never regrouping students instead making them work with their group mates the whole semester
Faculty of LPU 2	Division of labor among the members of each group; there is rotational leadership; not allowing regrouping
Students of LPU 2	Encouraging students to participate with their group mates; giving chance to those who are willing to be the leader to lead the group; not regrouping the members of the group
Faculty of LPU 3	Giving tasks to each member of the; asking a member of the group to help his group mate if he finished earlier; making students work with their group mates all throughout the semester; assigning anyone to be the leader of the group
Students of LPU 3	Requiring each member of the group to work on different procedure so as to finish the experiment at once; assigning leader by rotation
Faculty of LPU 4	Assigning leader for every experiment who monitors the performance of others; grouping is permanent in the whole semester; there is division of labor among members
Students of LPU 4	Asking the group leader to assign specific task for each

	member; giving everybody the chance to be the leader; not allowing students to transfer to another group

As shown from the table, all the four groups of faculty group their students into smaller groups. A leader is assign for every group and there is rotational leadership. However, these four groups of faculty never allow regrouping of students; instead the students work with their permanent group mates all throughout the semester. To compensate, all the four groups employ division of tasks among the members of the group.

The table also indicates that the teachers implement practices that develop teamwork skills among students. They group students into smaller groups possibly to enable students collaborate effectively with others in carrying out complex tasks. They also divide the tasks among the members of the group maybe to make students contribute and respond to ideas of others. Leadership is on a project basis so that students will assume different roles at different times. They do not allow regrouping of students but make them work with their permanent group all throughout the semester possibly because they want their students to establish harmonious relationship with their group mates and such relationship will lead to the success of the experiment.

Such findings are similar to those of Hall's (2006) study where a system was implemented in a way that specific roles were assigned to students during laboratory and a grade was given based on their level of contribution to the group. As observed by students, the teachers of the four groups of students group the class into smaller groups and assign a group leader for every experiment performed. All of them were not allowed by their teacher to regroup or transfer to another group during the whole semester.

The data proved that the teachers are implementing practices that develop the teamwork skills of students because these teachers want their students to interact with each other so that they can share their knowledge through performing specific tasks. This conforms with Kanli and Yagbasan (2008) laboratory principle of exchange where teachers prepare proper environment for students to discuss their ideas with their friends, observe and listen to students who are sharing their knowledge and ensure the interaction within student groups. The practices observed among the faculty that will develop teamwork skills of students are presented in Table 19.

Table 19. *Practices Observed Among Faculty to Develop Teamwork Skills Among Students*

Laboratory Practices	Mean	Verbal Interpretation
1. Making students collaborate effectively with others in carrying out complex tasks, share the work of the task, assume different roles at different times, and contribute and respond to ideas	3.00	Always
2. Making students work in the same group	2.75	Always

throughout the entire semester		
3. Allowing students to regroup during the semester	0.50	Never
4. Allowing students to take rotational and specific active roles in the group	3.00	Always
OVERALL MEAN	2.31	Always

As shown from the table, the teachers always implement those practices that got a mean of 3.00. Such practices are making students collaborate effectively with others in carrying out complex tasks, share the work of the tasks, assume different roles at different times, and contribute and respond to ideas; and allowing students to take rotational and specific active roles in the group. The practice making students work in the same group throughout the entire semester got a mean of 2.75 and is always implemented by the teachers. However, the teachers never allow students to regroup during the semester garnering a mean of 0.50.

As a whole, the overall mean of 2.31 was an indication that the teachers always implement practices that will develop students' teamwork skill. It could mean that these teachers are familiar with small group instruction which according to Hidalgo (2000) is an effective strategy that enhances cooperation, teamwork, leadership and group motivation among students.

II. Extent by which Students Manifest the Attainment of the Goals of Science Laboratory Instruction in their:

A. Attitude and Motivation

The extent by which students manifest the attainment of their interest in chemistry is reflected in Table 20. It can be gleaned from the table that the 80 students have positive attitude towards chemistry as indicated by the overall mean of 4.14 and a standard deviation of 0.42. The mean of their attitudes toward chemistry ranged from 3.54 to 4.41.

Table 20. ***Extent by which Students Manifest the Attainment of Interest in Chemistry***

Item	Mean	Standard Deviation	Verbal Interpretation
1. Learning chemistry requires a serious effort and special talent	4.41	0.71	Positive
2. Reasoning skills that are taught in chemistry can be helpful to me in my everyday life	4.14	0.74	Positive
3. For me doing well in chemistry courses depends on how well the teacher explains things in class	4.39	0.75	Positive
4. Understanding chemistry gives me a sense of			

accomplishment	4.31	0.63	Positive
5. Theories and scientific laws in chemistry are difficult to understand	3.54	0.93	Positive
6. How well I do in chemistry exams depends on how well I can recall material in the way it was presented in class	4.13	0.6	Positive
7. Learning chemistry has helped me to understand situations in my everyday life	4.08	0.85	Positive
OVERALL MEAN	4.14	0.42	Positive

It could mean that these students view chemistry as a subject which requires serious efforts and special talents because the theories and scientific laws are not easy to be understand. Further, the student could harbor the feeling that their achievement in chemistry depends not only on how they can recall materials but also on how their teacher presented or explain it in class. However, they believe that chemistry can help them in their everyday life and understanding the subject gives them a sense of accomplishment. This finding is similar to the idea of Zulueta and Guimbatan (2002) that students enjoy goal-oriented activities and practical work where they can see the relevance of abstract concepts and principles and consequently become interested in sciences. Table 21 presents the extent by which students manifest the attainment of their interest in learning chemistry.

Table 21. ***Extent by which Students Manifest the Attainment of Interest in Learning Chemistry***

Item	Mean	Standard Deviation	Verbal Interpretation
1. If I am having trouble learning chemistry, I try to figure out why	4.06	0.64	Highly motivated
2. I have a real desire to learn chemistry	4.08	0.71	Highly motivated
3. The subject has created a knowledge-base which will help me in my career	4.19	0.86	Highly motivated
4. I put enough effort into learning chemistry	3.95	0.78	Highly motivated
5. I use my imagination and creativity in doing scientific investigations	4.08	0.58	Highly motivated
6. The chemistry lecturers have made me feel			

that I have the ability to pursue my study in chemistry	4.12	0.64	Highly motivated
7. I am willing to master the knowledge and skills in chemistry course	3.74	0.85	Highly motivated
8. When learning chemistry, I prefer to put concepts/ideas in my own words	3.94	0.83	Highly motivated
OVERALL MEAN	4.02	0.48	Highly motivated

It appears from the table that 80 students are highly motivated by their teachers to learn chemistry as revealed by the overall mean of 4.02 and a standard deviation of 0.48. The mean of their motivations ranged from 3.74 to 4.19.

The results mean that these students have willingness to learn chemistry because they believe that chemistry has created a knowledge-base which will help them in their career as a result of the encouragement their teachers have given them to pursue their study in the subject. Their great desire to learn chemistry is reflected in them using their imaginations and creativity in doing scientific investigations, figuring out why they are having trouble learning chemistry, putting enough effort to learn chemistry by putting concepts/ideas in their own words and willingness to master the knowledge and skills in chemistry course.

The findings conform to Salandanan's (2002) statement saying that wholesome attitudes of students may be developed by awakening their interest and keeping them highly motivated to inquire about occurrence in the natural environment. She added that students must relentlessly pursue a scientific investigation and be responsible enough to complete an assigned task despite constraints.

The extent by which the attainment of the understanding of the nature of science is manifested by students is presented in Table 22. The students have much understanding of the nature of science as indicated by the overall mean of 3.91. The mean of their understanding ranged from 3.54 to 4.08. No matter how difficult the theories and scientific laws in chemistry are, still these students can understand situations in everyday life. It suggests that they have the ability to interpret data from the material world because they put concepts/ideas in their own words and use their imaginations and creativity to do scientific investigations.

Table 22. ***Extent by which Students Manifest their Understanding of the Nature of Science***

Item	Mean	Standard Deviation	Verbal Interpretation

1. Theories and scientific laws in chemistry are difficult to understand	3.54	0.93	Much understood
2. I use my imagination and creativity in doing scientific investigations	4.08	0.58	Much understood
3. When learning chemistry, I prefer to put concepts/ideas in my own words	3.93	0.83	Much understood
4. Learning chemistry has helped me to understand situations in my everyday life	4.07	0.85	Much understood
OVERALL MEAN	3.91		Much understood

These findings are in consonance with the statement of Crowther, et al. (2005) that in teaching scientific laws, teachers must emphasize how these laws describe nature and how things act under certain conditions. It should be taught also that questions lead to investigation and experiments then lead to conclusions - but still there are many different pathways that scientists take.

B . Laboratory Skills

The extent by which the students manifest the attainment of practical skills is shown in Table 23.

Table 23. ***Extent by which Students Manifest the Attainment of Practical Skills***

Skills	Number of Groups of Students	Percent	Verbal Interpretation
A. Handling Liquids and Measuring Volume			
1. Places the cover of the reagent bottle on the table in an upside down position	18	100	Highly competent
2. Uses a pipette correctly in getting liquid chemicals from the reagent bottle	16	89	Highly competent
3. Reads the volume of liquids precisely using a graduated cylinder	12	67	Competent
4. Measures exact volume of liquids with a pipette	13	72	Competent
Average	15	82	Highly competent
B. Handling Solids and Weighing			Moderately

1. Sets the scale to zero before starting to weigh	6	33	competent
2. Places the object on the left pan and the set of masses on the right pan	18	100	Highly competent
3. Uses a dry spatula in getting solids from the reagent bottle	14	79	Highly competent
			Highly competent
4. Avoids using bare hands in handling chemicals	16	89	
			Highly competent
5. Obtains accurate weight using platform balance	14	79	Moderately competent
6. Uses a paper lining in introducing solids into test tube	6	33	
7. Avoids returning unused reagents to the reagent bottle	13	72	Competent
			Competent
8. Discards solid wastes into an appropriate waste container	11	61	
	12	67	Competent
Average			
C. Bunsen Burner Manipulation			Moderately competent
1. Lights the Bunsen burner properly by closing the air inlet then lighting the burner from the side of the barrel going up	7	39	Highly competent
2. Regulates the amount or flow of gas properly so as to get an ideal height of the flame	15	83	Highly competent
3. Produces a non-luminous flame by opening the air inlet	18	100	
			Competent
Average	13	74	
D. Heating Substances in a Test tube and Doing Evaporation	18	100	Highly competent
1. Heats the test tube in an inclined position (45° angle) moving it back and forth while heating			Highly competent
2. Not pointing the mouth of the test tube to anybody while heating	16	89	Highly competent
3. Follows the proper set-up for evaporation	16	89	
			Highly competent
Average	17	93	
E. Doing Filtration			Highly competent
1. Folds the filter paper correctly	18	100	Highly competent
2. Follows the proper set-up for filtration	16	89	
			Highly competent
Average	17	95	
F. Safety Considerations			Highly competent

1. Wears lab gown properly 2. Wears appropriate goggles all the time 3. Wears appropriate clothes and footwear	18 3 18	100 17 100	Not competent Highly competent
Average	13	72	Competent
Overall Percent		81	Highly competent

It can be noted from the table, that as to handling liquids and measuring volume, 18 groups of students or 100 % placed the cover of the reagent bottle on the table in an upside down position; 16 groups or 89 % used a pipette correctly in getting liquid chemicals from the reagent bottle; 13 groups or 72 % measured exact volume of liquids with a pipette; and 12 groups or 67 % read the volume of the liquids precisely using a graduated cylinder.

As a general view, about 15 groups or 82 % of the students are highly competent in handling liquids and measuring volume. It could be that these students had acquired skills in handling liquids and measuring volume even when they were still in high school because they have already performed similar laboratory activity before. This finding affirms Marine's (2003) idea that if an experiment is repeated it can greatly help students to understand or improve their laboratory techniques.

As to handling solids and weighing, 18 groups or 100% placed the object on the left pan and the set of masses on the right pan; 16 groups or 89 % avoid using their bare hands in handling chemicals; 14 groups or 79 % used a dry spatula in getting solids from the reagent bottle and obtained accurate weight using platform balance; 13 groups or 72 % avoid returning unused reagents to the reagent bottle; 11 groups or 61 % discarded solid wastes into an appropriate waste container; and 6 groups or 33 % only set the scale to zero before starting to weigh and used paper lining in introducing solids into test tube.

In sum, only 67 % or 12 groups of students are competent in handling solids and weighing. It seems that not all students have acquired the necessary skills in handling solids and in weighing as justified by the number of students who were able to set the scale to zero before weighing and those who used paper lining in introducing solids into test tube. This can mean that these students are careless in following the correct techniques that they always work in a hurry for the purpose of finishing the experiment at once without considering the accuracy of what they are doing. They do not understand measurement error which may affect the result of their experiment. This finding conforms with Singer's, et al. (2005) recommendation to teachers to help students learn to address the challenges inherent in directly observing and manipulating the material world including the understanding of measurement error.

In terms of Bunsen burner manipulation, 18 groups or 100 % were able to produce a non-luminous flame by opening the air inlet; 15 groups or 83 % were able to regulate the amount or flow of gas properly so as to get an ideal height of the flame; while only 7 groups or 39 % light the Bunsen burner properly by closing the air inlet then lighting it from the side of the barrel going up.

In general, only 13 groups or 74 % of the students are competent in manipulating the Bunsen burner. This can be a clear indication that although students are familiar with the use of a Bunsen burner, still not all of them know how to light it properly. It could be that these students were not listening nor watching the demonstration made by their teacher during pre-lab discussion on the proper way of lighting the Bunsen burner. Demonstration method according to Garcia as cited by Acero, et al. (2000), is an imitative method where learning a skill is faster and more effective since students are shown how the job is done by using actual tools, machines and materials.

As regards the skill heating substances in a test tube and doing evaporation, 18 groups or 100 % of students heated the test tube in an inclined position moving it back and forth while heating; 16 groups or 89 % were not pointing the mouth of the test tube to anybody while heating and followed the proper set-up for evaporation. Almost 17 groups or 93 % of the students are highly competent in heating substances in a test tube and doing evaporation. It appears that these students had encountered minor accidents on heating substances in a test tube and evaporation during their high school chemistry that they now developed the proper techniques from their previous mistakes. This affirms Jona's (2008) statement that mistakes encountered by students during experiments are not hindrances but they are opportunities for greater learning.

On the other hand, doing filtration is easy for 18 groups or 100 % of the students who were able to fold the filter paper correctly while 16 groups or 89 % followed the proper set-up for filtration. Thus, 17 groups or 95 % of the students are highly competent in doing filtration. It suggests that the students have acquired the skills in filtration because they were taught about the principles of filtration and how to do filtration. These findings affirm Moni's, et al. (2007) idea that students must be taught of the differences among "knowing about" a topic, "knowing how" to complete a skill, "showing how" to complete a skill and "doing" the skill. This is done through integration of skills development with conceptual learning.

In terms of safety considerations, 18 groups or 100% of the students wore laboratory gown properly and appropriate clothes and footwear while 3 groups or 17 % only wore appropriate goggles all the time. As a whole, only 13 groups or 72 % of the students are competent with regards to safety considerations. It could mean that those students found it inconvenient to wear goggles while doing experiments since they are not used to it aside from they were not given strict implementation on its use. This is in contrary to NSTA's (2007) suggestion to teachers of giving the students opportunities to develop safe and conscientious laboratory habits and procedures. In general, the students are highly competent in their practical skills as justified by an over-all percentage of 81 %.

Table 24. ***Extent by which Students Manifest the Attainment of Teamwork Skills***

Skills	Number of Groups of	Percent	Verbal Interpretation

	Students		
1. Tries to get other team members involved	16	89	Highly Competent
2. Presents ideas about how to work on the task	8	44	Moderately Competent
3. Enjoys working on the team	16	89	Highly Competent
4. Questions other's task ideas constructively	8	44	Moderately Competent
5. Tries to get other team members to voice their opinions about ideas on the table	8	44	Moderately Competent
6. Responds calmly to others	16	89	Highly Competent
7. Tries to raise alternatives that weren't on the table	6	33	Moderately Competent
8. Helps explain other ideas	14	78	Highly Competent
9. Integrates ideas of different members	12	67	Competent
10. Responds appropriately to any questions presented in the group	16	89	Highly Competent
Overall Percent		67	Competent

The extent by which the students manifest the attainment of teamwork skills is shown in Table 24. It can be gleaned from the table that out of the 18 groups of students, only 16 groups or 89 % tries to get other team members involved; enjoys working on the team; responds calmly to others; and responds appropriately to any questions presented in the group. Fourteen groups or 78 % help explain other ideas while twelve groups or 67 % integrate ideas of different members. Eight groups or 44 % present ideas about how to work on the task; question other's task ideas constructively; and try to get other team members to voice their opinions about ideas on the table. Only 6 groups or 33 % try to raise alternatives that weren't on the table.

To sum up, only 12 groups or 67 % of the students are competent in their teamwork skills. It seems that not all students attained teamwork skills because they did not demonstrate a true collaborative work. It reflects that they work in group for the purpose of dividing limited laboratory equipment and space among a large number of students. This is contrary to NRC's (2005) idea of teamwork that requires high level of substantive conversation. There is high level of substantive conversation if there is considerable interaction about the ideas of a topic and if there is sharing of ideas.

Table 25 presents the extent by which students manifest the attainment of the understanding of complexity and ambiguity of empirical work. It can be noted from the table that 18 groups or 100 % of students have knowledge on troubleshooting equipment. Seventeen groups or 94 % take notice of deviations from expected values. Fifteen groups or 83 % take notice of experimental errors due to equipment failure while only 7 groups or 39 % take notice of precision issues and accuracy issues. It appears that almost all of the 13 groups or 71% of the students understood the complexity and ambiguity of empirical work because they can find solutions to problems encountered while doing experiments as in troubleshooting equipment. It could be that they were given proper instructions on the proper use and maintenance of equipments. Most of them can take notice

Table 25. ***Extent by which Students Manifest the Attainment of the Understanding of Complexity and Ambiguity of Empirical Work***

Skills	Number of Groups of Students	Percent	Verbal Interpretation
1. Has knowledge on troubleshooting equipment	18	100	Highly Understood
2. Takes notice of precision issues	7	39	Much Understood
3. Takes notice of accuracy issues	7	39	Much Understood
4. Takes notice of experimental errors due to equipment failure	15	83	Highly Understood
5. Takes notice of deviations from expected value	17	94	Highly Understood
Overall Percent		71	Understood

of deviations from expected result and can take notice of experimental errors due to equipment failure possibly because their teachers have emphasized to them that errors cannot be avoided when performing experiment. Instead students must know how to deal with these experimental errors. This conforms with Jona's, et al. (2008) statement that a well designed scientific investigation must allow students to understand measurement error.

C. Achievement in Chemistry

Table 26 shows the extent by which the students manifest the attainment of mastery of subject matter and of scientific reasoning.

Table 26. ***Extent by which Students Manifest the Attainment of Mastery of Subject Matter and Scientific Reasoning***

Goal of Instruction	Mean					Percent
	LPU 1	LPU 2	LPU 3	LPU 4	Average Mean	
Enhancing Mastery of Subject Matter	11.91	11.84	12.54	14.23	12.63	60.14
Developing Scientific Reasoning	28.78	23.33	22.18	22.15	24.11	63.45

It can be noted from the table that enhancing mastery of subject matter got an average mean of 12.63. Out of the 21 questions about mastery of subject matter, the highest score obtained by the students is 18 and the lowest score is 7. Students from LPU 4 got the highest mean of 14.23 while students from LPU 3, LPU 1 and LPU 2 got a mean of 12.54, 11.91 and 11.84 respectively. It appears that the students have attained an average level of mastery of subject matter as justified by the mean of 12.63 which is about 60.14 %.

Developing scientific reasoning got a mean of 24.11. Out of the 38 questions about scientific reasoning, the highest score obtained by the students was 36 and the lowest score was 10. Students from LPU 1 got the highest mean of 28.78 while students from LPU 2, LPU 3 and LPU 4 got a mean of 23.33, 22.18 and 22.15 respectively. It appears that the students had attained an average level of scientific reasoning because the mean is 24.11 which is about 63.45 %.

The students attained an average level of mastery of subject matter because they can readily understand and apply the concepts they have learned. It could be that their teachers taught content and process simultaneously. This affirms Jona's, et al. (2008) idea that mastery of subject matter could be attained if concept and processes are taught simultaneously so that in performing a process the student has clear understanding of the relation of that process to content.

The students attained an average level of scientific reasoning possibly because they were trained how to construct scientific arguments where they will use their reasoning skills. This is in consonance to Jona's, et al. (2008) statement that students should be taught of the various scientific processes and valid reasoning principles and at the same time must be given opportunities to practice those reasoning skills.

III. Model of Teaching Practices in Chemistry Laboratory to Attain the Goals of Science Laboratory Instruction

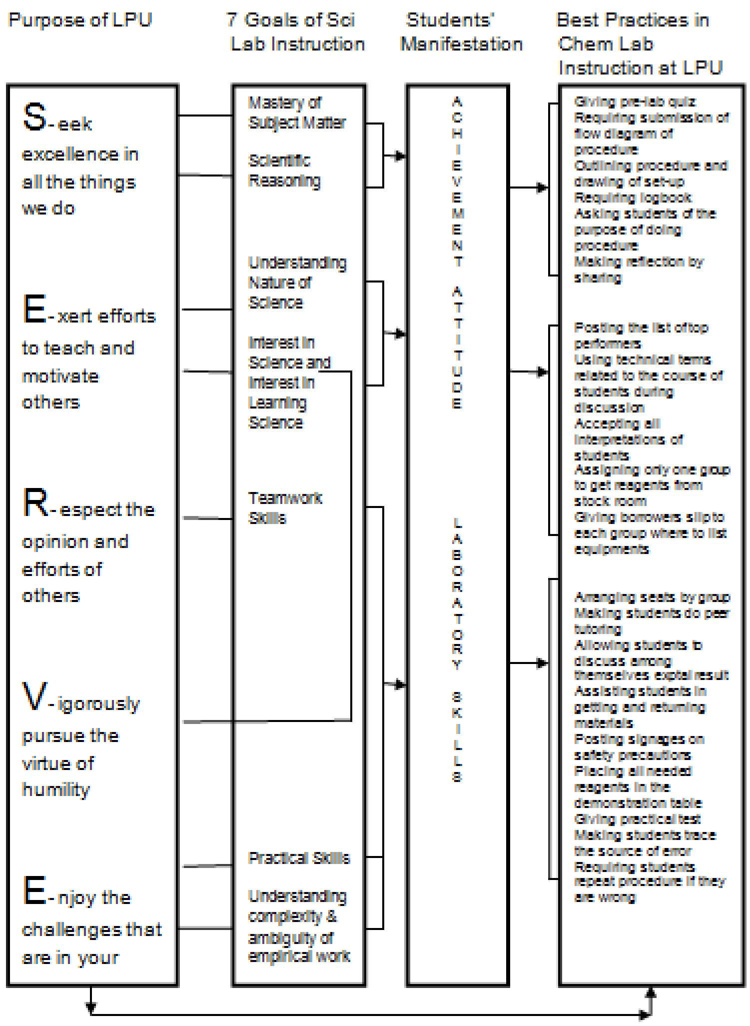
Laboratory experiences in chemistry are important for students to gain a deeper sense of understanding and a greater confidence in learning. With the acknowledged importance of a laboratory experience for all students, it is necessary for chemistry teachers to conceptualize clearly the elements that make up an effective and well-designed laboratory instruction.

The chemistry faculty of the Lyceum of the Philippines University strive to provide their students with access to a more authentic laboratory experience by complying with the university's vision, mission, goal and objective (VMGO). The design of their instruction is tailored in accordance with what is stated in the purposes of the university. The university VMGO was simplified using the acronym **S-E-R-V-E** to make it more realistic for all stakeholders. Each letter in the acronym has a corresponding meaning on which the faculty patterned their teaching practices and strategies.

Based from the findings of the present study, the LPU faculty, although did not fully implement the ideal practices as stated in the seven goals of science laboratory instruction, were still able to develop students' positive attitude, laboratory skills and high achievement in chemistry. This could be due to the uniqueness of their teaching practices that were anchored on the university's VMGO which are parallel to the seven goals of science laboratory instruction.

A model of teaching practices in chemistry laboratory was proposed from the identified best teaching practices of chemistry faculty of LPU with the hope of contributing to the body of knowledge in science education. The identified best teaching practices of chemistry faculty of LPU are shown in Figure 3. The figure consists of four rectangular boxes. The first box shows the purposes of LPU which were embodied in its VMGO.

Figure 3. Best Practices in Chemistry Laboratory Instruction at Lyceum of the Philippines University



Letter **S** means to seek excellence in all the things that we do; **E** means to exert efforts to teach and motivate; **R** means to respect the opinion and efforts of others; **V** means to vigorously pursue the virtue of humility; and **E** means to enjoy the challenges that are in your hands. The second rectangular box contains the seven goals of science laboratory instruction. Each purpose in the first box is connected by a line to a goal or goals in the second box to indicate that the purposes of LPU are parallel with the seven goals of science laboratory instruction. The third rectangular box represents the students' manifestation of the attainment of the goals of science laboratory instruction in their achievement, attitude/ motivation, and laboratory skills. Arrows connect the goals in the second box to the third box to indicate that the goals of science laboratory instruction are attained if they are manifested in the high achievement, positive attitude, high motivation and competencies in laboratory skills of students. A fourth and final rectangular box contains the identified best teaching practices of the chemistry faculty of LPU which were anchored on the purposes of the university.

Twenty best teaching practices of LPU chemistry faculty were identified and were categorized under each purpose. Since each purpose is parallel to the goals of science laboratory instruction, this means that although the LPU faculty did not fully implement the ideal teaching practices stated in the goals of science laboratory instruction, they were still able to attain those goals as manifested in the achievement, attitude, motivation and laboratory skills of their students.

In order to seek excellence in all the things being done, the LPU chemistry faculty, in designing their laboratory instruction, integrate teaching practices that will attain the mastery of subject matter and scientific reasoning and will lead to the high achievement of students in chemistry. Enhancement of mastery of subject matter may be attained by giving a pre-lab quiz to students before conducting a pre-lab discussion; requiring students to submit a flow diagram of the procedure of the experiment prior to its actual performance; outlining the procedure and drawing the experimental set-up on the board; and requiring students to make a logbook of the experiments. By simply giving a short pre-lab quiz at the start of the class where students will be asked to give the title of the experiment, the reagents and equipments to be used and even the objectives of the experiment, the teacher assesses if the students read the experiment and already have an idea about the experiment. Diagnostic, formative assessments when embedded into the instructional sequences can be used to gauge students' understanding. Requiring students to submit a flow diagram of the procedure prior to the actual performance of the experiment will enable the student to organize information that will increase the students' retention of concepts. A chemistry laboratory teacher must outline the procedure and draw the experimental set-up on the board in order to make students understand the process and make the learning outcomes clear to the learners. Students must be required to make a logbook of the experiment where they can record not only the results of their experiment but also the learning they got from the experiment. With this logbook, students can make multiple representations that will show the correlation between the results of the experiment and the concepts previously learned.

Teaching practices implemented by LPU chemistry faculty that will attain the development of students' scientific reasoning are asking students the purpose of doing a certain procedure while performing an experiment; and making students reflect on their own learning by sharing their experiences while doing the experiment to the other groups of students during post-lab discussion. Students are trained to use their reasoning skills when they were asked on the purpose of doing such a procedure. The use of student reflection and discussion signify that the faculty supports metacognition and student self-regulation where they can control their own learning.

In exerting efforts to teach and motivate, the LPU chemistry faculty implement teaching practices to attain the interest of students in science and their interest in learning science and also the students' understanding of the nature of science. This in turn will lead to a positive attitude and high motivation of students in chemistry. The students' interest in learning science can be developed if the faculty post the list of the top 10 or top performers on the door outside the laboratory room after each major examination or after the midterm grade had been released; and the teacher uses technical terms related or appropriate for the course of the student during pre-lab and post-lab discussion. Students will be inspired and motivated to strive harder in learning chemistry if his name is included in the list of top performers. Using technical terms appropriate to the course of the students will enable the students see the relevance of the subject to their future job thereby motivating them to pursue their study.

A teaching practice implemented by LPU chemistry faculty that will attain the students' understanding of the nature of science is the faculty accepts all the interpretations made by each group regarding the experimental data obtained without telling the students that they are wrong. In this way, the teacher can emphasize to the students that different people may interpret the same data differently depending on the steps they followed in making their scientific investigations.

Respecting the opinion and efforts of others so that they will also respect yours is also very important in developing teamwork skills among students. The LPU chemistry faculty inculcate this virtue of respecting one another leading to the development of teamwork skills of students by implementing practices such as properly arranging the seats so that students can join their group mates not only during the actual performance of the experiment but also during pre-lab and post-lab discussion; asking the bright student in each group to guide his group mates and do peer tutoring; allowing students to discuss among themselves the result of the experiment before recording it on the data sheet; and assisting students in getting and returning materials from the stock room. If students are seated together with their group mates from the start until the end of the class, they will become close to each other so that there will be harmonious relationship in the group and they will enjoy working as a team. Peer tutoring is necessary to help explain other ideas. Students try to get other team members to voice their opinions and integrate ideas of different members when they are allowed to discuss among themselves the results of the experiment. The respect for the opinions of others can be observed when students respond calmly to their team mates and question other's opinions or ideas constructively. If the teacher assists the students in getting and returning materials from the stockroom, she demonstrates the value of cooperation which is very important in developing team work skills.

To vigorously pursue the virtue of humility is a purpose of LPU chemistry faculty where humility is considered as the very foundation of leadership of a teacher so that a teacher can influence the behavior or attitude of students. In influencing the behavior of students, the LPU chemistry faculty employs teaching practices that lead to the interest or positive attitudes of students in science. These teaching practices of LPU chemistry faculty are assigning only one group instead of the whole class to get the reagents from the stockroom; and giving a borrower's slip to each group for them to list the needed equipment that will be borrowed from the stockroom. Only one group from the class was assigned to get the reagents and this group is responsible for distributing the reagents to the other groups. In this way, the students are taught the positive attitude of responsibility and willingness to share the resources to others. Proper enlisting of equipments in the borrower's slip is one way of training the students to be organized and systematic in what they are doing.

Finally, LPU chemistry faculty also gear to make students enjoy the challenges that are in their hands because they will make them a better and complete person. In so doing, the LPU chemistry faculty implement teaching practices that lead to the development of practical skills of students and their understanding of the complexity and ambiguity of empirical work. The teaching practices that lead to the development of practical skills include providing posters and signages on safety precautions in the laboratory room such as "No Lab gown, no entry", "Place your bags in the shelves or tables provided for at the back of the room", and "Check the gas supply before and after using"; placing all the needed reagents in the demonstration table for the teacher to see the amount of reagents the students will get; and giving practical test on the proper use of equipment such as Bunsen burner, pipette and platform balance. Posting signages on safety precautions will help students develop safe and conscientious laboratory habits which is one of the practical skills a student must acquire in science education classes. Another important practical skill is for the student to use the exact amount of reagents as indicated in the procedure to avoid wastage, contamination and inaccuracy of result. Practical test is given to check if students acquired the skill in using simple equipment such as proper lighting of Bunsen burner, measuring accurate volumes of liquids with a pipette and getting exact weight of reagents in a platform balance. These are fundamental skills which are necessary for the success of an experiment.

Teaching practices of LPU chemistry faculty that lead to the students' understanding of the complexity and ambiguity of empirical work include making students trace the source of their error in the result of the experiment and requiring students to repeat the procedure if they got a result which is far beyond the actual value. By allowing students to trace the source of error, they will recheck data observations which will enable them to expect and understand experimental error in every scientific investigation. Requiring students to repeat the procedure makes them correct their own mistakes. In this way, a teacher can emphasize to students that experimental errors are not hindrances to learning but they are opportunities for greater learning.

Figure 4 is a proposed model of constructivist teaching-learning approach based on the identified best teaching practices in chemistry laboratory. It consists of three rectangular boxes connected by arrows. The first box represents the constructivist teaching approach containing the four elements of constructivism such as interweaving, scaffolding, modeling and coaching. The second box shows the four elements of constructivism which are included in the constructivist learning environment such as collaboration, articulation, reflection and exploration. The seven goals of science laboratory instruction which include mastery of subject matter, scientific reasoning, understanding the complexity and ambiguity of empirical work, practical skills, understanding the nature of science, interest in science and interest in learning science and teamwork skills are contained in the third box.

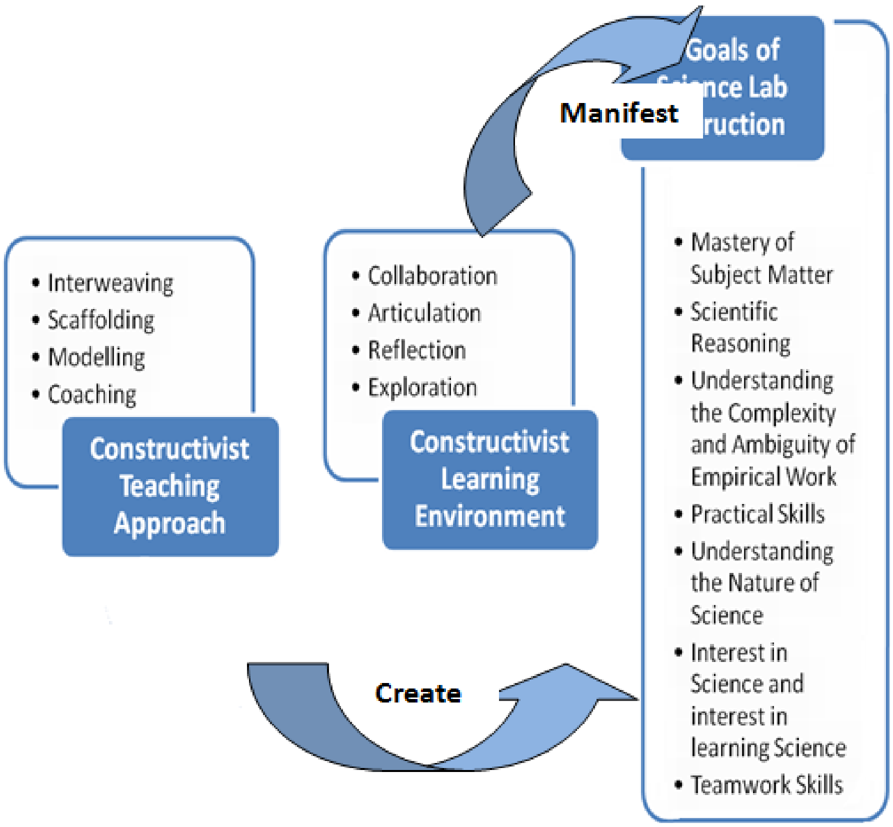


Figure 4. Proposed Model of Constructivist Teaching-Learning Process Based on the Best Teaching Practices in Chemistry Laboratory Instruction

An arrow linking the first box to the second box shows that a constructivist teaching approach creates a constructivist learning environment. Another arrow linking the second box to the third box shows that a constructivist learning environment manifests the seven goals of science laboratory instruction. It means that if a constructivist teacher implements teaching practices based on the seven goals of science laboratory instruction then the students will manifest the attainment of the seven goals of science laboratory through constructivist learning.
Based on the findings of the study, the best teaching practices of the chemistry faculty of LPU which are based on the university's VMGO are parallel to the ideal practices which on the other hand are based on the seven goals of science laboratory instruction. This means that constructivist teaching could be attained if the ideal practices and the best teaching practices from LPU are both implemented. Both practices lead to the enhancement of mastery of subject matter, developing of scientific reasoning, interest in science and interest in learning science, understanding the nature of science, developing teamwork skills, practical skills and understanding the complexity and ambiguity of empirical work.

Interweaving is connecting of new ideas to prior knowledge in order to make learning meaningful. The best practices of the LPU faculty such as giving of pre-lab quiz and submission of flow diagram by their students together with the ideal practices based on the seven goals such as making the topic in the lecture simultaneous with the laboratory and conducting of pre-lab discussion, all of which lead to the enhancement of the mastery of subject matter. The practice of giving a pre-lab quiz will enable a teacher to diagnose what is already known by the student so that they can relate new knowledge (concepts and propositions). Submission of flow diagram of the procedure make students organizes information into a meaningful whole. When the topic in the lecture is simultaneous in the laboratory, the knowledge acquired is applied in the experiment so that concept and process are taught simultaneously. Conducting a pre-lab discussion will enable the teacher to find out what the pupils know about the topic before doing the experiment. Such practices lead to the enhancement of mastery of subject matter.

Scaffolding is accomplished by giving assistance to students in achieving tasks that they cannot yet master on their own and then gradually withdraws the teacher's support. Best practices of LPU faculty such as assisting students in getting and returning materials and asking students of the purpose of doing such a procedure are examples by which scaffolding is done. Assisting students in getting and returning materials makes students develop teamwork skills while asking students of the purpose of doing such a procedure develop their scientific reasoning. Other best teaching practices of LPU faculty such as posting of signages about safety precautions, and placing needed reagents in the demo table are also implemented during scaffolding which lead to the development of practical skills of students. On the other hand, ideal practices based on the seven goals of science laboratory instruction were also implemented by LPU faculty, and these are checking and troubleshooting of equipment before the experiment, not skipping experiments simply because the materials are not available and supervising and guiding students in performing experiment.

During modeling, the teacher performs a complex task to show the students the processes needed in carrying out the experiment. The best practice of LPU faculty of outlining the procedure and drawing of set-up of the experiment on the board make students learn large amounts of meaningful material from textual representations thus enhancing mastery of subject matter. Developing practical skills of students such as checking whether students know how to operate lab equipment and understand exactly how equipment works before physically approaching it, may also be implemented during modeling and these conform to the ideal practices based on the seven goals of science lab instruction.

Coaching is a process of motivating learners, analyzing their performance, and providing feedback on their performance. The best practices of LPU faculty which are included under this process are posting of top performers, using technical terms related to the course of the students during discussion, accepting all interpretations made by each group about the result of the experiment, giving of practical test and requiring students repeat procedures if they got wrong result. Posting of top performers and using technical terms related to the course of the students during discussion will develop students' interest in science and interest in learning science. Ideal practices based on the seven goals of science laboratory instruction include emphasizing the relevance of the lesson to the students' future job, making the objective of the experiment clear to the students before doing the experiment, listing down keywords on the board, advising students to overcome their errors, emphasizing to students that each person's preconception may or may not affect conclusion and giving of post-lab quiz. A post – lab quiz and practical test are given to analyze and provide feedback for the performance of the students.

In collaboration, students learn from each other such as when their seats are arranged by group and when they are allowed to do peer tutoring. When students are grouped into smaller groups, a leader is assigned for every group, everyone is given specific active roles and not allowing students to regroup are examples of collaboration. In so doing, students develop teamwork skills. Assigning only one group of students to get the reagents and share with the rest of the class, and listing equipments needed in the borrowers slip may be implemented during collaboration. These practices lead to the development of practical skills. Among the best practices of LPU faculty are arranging the students by group, allowing them to do peer tutoring, assigning only one group of students to get the reagents, and making them list the equipments needed in the borrowers slip. On the other hand the ideal practices based on the seven goals of science lab instruction include grouping students into smaller groups, assigning a leader for every group, allowing students to do rotational and specific active roles, and not allowing students to regroup.

During articulation, students are encouraged to articulate their ideas, thoughts and solutions. They are allowed to think about the method they use in doing the procedure and whether this method arrived to the correct result. Best practices of LPU faculty such as requiring students to submit logbook, allowing them trace error and repeat the procedure if they got wrong result may be implemented during articulation. Submission of logbook enhances mastery of subject matter, while tracing error and repeating procedure if students got wrong result makes them understand the complexity and ambiguity of empirical work.

During reflection students compare their results with other students. Practices such as making students do reflection by sharing and making them discuss results may be implemented during reflection. Making reflection by sharing develops scientific reasoning. Developing students' understanding of the nature of science as in accepting all their interpretations of experimental result may also be implemented during reflection. During post-lab discussion students can compare results, give scientific explanations for their result, analyze and discuss the data and observations. Among the best practices of LPU faculty is making students do reflection, accepting all interpretations made by students about experimental result, and discussing among themselves experimental result. On the other hand the ideal practices based on the seven goals of science lab instruction include conducting post-lab discussion, allowing students compare result, making students give scientific explanations for their result and making students analyze and discuss the data and observation.

In exploration, students develop novel combinations of ideas and thinking about hypothetical outcomes of imagined situations and events. In the logbook that students are required to submit, they must include the possible application of the experiment to other situations and they can propose investigatory studies related to the experiment. That is one of the best practices of LPU faculty which lead to the enhancement of mastery of subject matter. Ideal practices such as going on field trips, and connecting the lesson to real world experiences are also exploration.

Conclusions

Based on the findings of the study, the following conclusions are drawn:

1. The teaching practices employed by the faculty in teaching chemistry laboratory that attain the seven goals of science laboratory instruction are those practices where students engaged in:

    a. experiential learning where experience is translated through reflection into concepts, which are used as guides for active experimentation

    b. active learning or learning by doing where learners use their learning in realistic and useful ways, seeing its importance and relevance

    c. meaningful learning where learners organize information through integrating new and previous knowledge and

    d. cooperative learning where students work as self-directed in small collaborative groups

2. Students enjoy goal-oriented activities and practical work, have willingness and great desire to learn chemistry and can understand situations in everyday life no matter how difficult the theories and scientific laws in chemistry are.

Students can recognize the differences among "knowing about" a topic, "knowing how" to complete a skill, "showing how" to complete a skill and "doing" the skill. They demonstrate true collaborative work and interaction through sharing of ideas. They know how to deal with experimental errors and can find solutions to problems encountered while doing experiments

Students can readily understand and apply the concepts they have learned. They are aware of valid reasoning principles and can practice those reasoning skills.

Recommendations

In the light of the findings of the study, the following recommendations are endorsed:

1. The model of teaching practices be used by chemistry faculty in designing their laboratory instruction to develop students' positive attitude towards chemistry, laboratory skills and high achievement in the subject.

2. The findings of this study could be an avenue for chemistry faculty in maximizing the active participation of students in the laboratory by incorporating the significant findings of the study in training and seminars of chemistry faculty.

3. An in-depth study can be conducted in other science subjects that will determine the best practices in its laboratory instruction.

4. The significant findings of this study may be integrated as a guide in developing instructional materials in chemistry.

5. Curriculum planners may include the salient findings of this study as a concrete basis in determining the objectives and methods in the design of chemistry laboratory instruction.

6. Policy makers may utilize the findings of this study as a guideline in considering the educational purposes that science education can best provide to students.

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