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Laboratory Behavior Strategies in Relation with the Inquiry Skills of College Chemistry Students

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ABSTRACT

This investigation was initiated to explore the relationship of Laboratory Behavior Strategy of college students taking Chemistry with their Inquiry Skills. The task was to identify the laboratory behavior of chemistry students using the parameters of activity-oriented science classrooms such as planning and design, manipulative skills and conduct of experiment, observations and recording of data, interpretation of data, responsibility, initiative and work habits in relation with their inquiry skills. There were 91 College Students taking 5-units General College Chemistry with Laboratory component who participated in the study: 25 BSE Biology Majors; 28 BSN students; and 38 BALS Food Tech students during the Second semester, School Year 2016-2017.

The findings show that Laboratory Behavior Strategy was always practiced by the students. They had attained approaching proficiency level in their inquiry skills. There was low yet significant relationship of the Laboratory Behavior Strategy with the Inquiry Skills of the students. This suggests other possible factors that could associate with the Inquiry Skills, which need to be explored in further research.

Keywords: *Laboratory Behavior, Inquiry Skills, Chemistry, College Students, Strategies*

RATIONALE

The learning of Chemistry theories is facilitated where practical activities are accepted as integral part of the learning process. Laboratory activities could be used to provide students with concrete experiences in handling and manipulating materials familiar to them. Laboratory activities could enable the students develop science process skills. This is expected to enhance their abilities to think logically and clearly, and sharpen their abilities to solve problem and develop their creativity.

Laboratory work is an essential component of most science courses, but little, if ever, had been done to investigate how student laboratory behavior strategies actually facilitate learning. Students seem to experience difficulty in integrating their understanding of chemical concepts gained in the lecture with the physical phenomenon observed in the laboratory. Perhaps, this difficulty could arise from the laboratory being a complex-information rich environment. It could be that students are overwhelmed in their efforts to process the information effectively. The cited situation accentuates the need to obtain more understanding of the procedures of laboratory instruction.

Laboratory work is a very important component in chemistry learning. However, the students' reactions often indicate either preference or non-preference to laboratory work. It is quite common to hear students say that laboratory activities are boring and that they go

through the motions of experimentation without simulation and often without clear purpose. This necessitates the need to know more about the influence of laboratory instruction and student behavior upon student's learning outcome, – behavior or attitude.

Researches have been made investigating laboratory the environment and other dimensions of the laboratory as a component of science teaching. While studies had been done to investigate laboratory interaction behavior of students, little has been made to examine the relationship of laboratory behavior with the inquiry skills of the Chemistry students. The need to study laboratory behavior of students is emphasized since research suggests the role of laboratory work in science teaching.

The importance of examining such relationship would provide insight into that student laboratory behavior which facilitates the acquisition of inquiry skills. This could provide understanding of the dynamics of laboratory instruction. It could assist the laboratory teacher to emphasize the practice of those laboratory behaviors by students.

FRAMEWORK OF THE STUDY

The science laboratory is important in the development of conceptual knowledge and skills in science (Bybee, 2000). Fraser, et al (1993) earlier claimed that student interaction in the science laboratory could enhance the cognitive and affective domains as well as the practical outcomes and skills of students. The laboratory interaction strategies can considerably influence the total learning performance and skills development of students (Ogena & Brawner, 1998).

The constructive social relationships, cognitive growth, positive attitudes and skills can be developed through laboratory activities because the students experience a less formal social environment than in a conventional classroom. Laboratory activities give the students opportunities to manipulate equipment and materials suitable for them to construct knowledge of phenomena and related science concepts, and develop science skills (Tobin, 1990). Moreover, Gunstone and Champagne (1990) claimed that learning in the laboratory would occur if students are given ample time and opportunities for interaction and reflection in order to initiate discussion. The challenge is to help learners take control of their learning in their search for understanding.

The laboratory activities that allow student interaction could enhance the development of inquiry skills. It is vital to provide opportunities that encourage the learners to ask questions, suggest hypothesis, and design investigation – "minds on as well as hands-on." Inquiry skill, as claimed by Baybee (2000), is the search for truth and knowledge. For the students, inquiry skill would enable them to imitate as closely as possible the scientists and their method of inquiry. Minstel, et.al (2004) cited that observation, experiment, replication, and laboratory experiences are the process for developing inquiry skills.

The use of inquiry skills or scientific processes helps the students to confront problems for a lifetime. The inquiry skills or science processes are particularly appropriate for the students to practice for learning. Dewey (1910) in Hofstein and Lunneta (2003) earlier advanced the notion that the process or method of learning is by doing and by solving problem. This emphasizes inquiry teaching and the use of student interaction in the classroom to develop inquiry skills.

PROBLEM STATEMENT

The study sought answers to the following questions:

1. How do the Students assess the extent of practice of Laboratory Behavior in Chemistry?
2. What is the Inquiry Skills level of the Students in Chemistry?
3. Is there a significant relationship of the Laboratory Behavior with the Inquiry Skills of Students in Chemistry?

METHODOLOGY

The study was conducted during the first semester of school year 2016 to 2017. This involved 3 classes of students taking up a 5-unit General College Chemistry course with Laboratory component. The classes had laboratory activities as component of their Chemistry instruction. There were 25 BSE students with majors in General Science, 28 BSN students and 38 BALS students with majors in Food Technology who participated in the study.

A 25-item Inquiry Skills test was used to assess the Inquiry Skills of the students. A questionnaire on Laboratory Behavior Strategies was used to assess the extent of Laboratory Behavior of the Students in Chemistry. The students perceived the extent of practice of their Laboratory Behavior.

Prior to the conduct of the study, proper protocol was observed. Permission to conduct the study was secured from the University President through the CAS Dean and the NSD Chair. Upon approval for the conduct of the study, research ethics was followed. The students taking College Chemistry with Laboratory Component, as participants of the study, were provided with informed consent form. The Informed Consent Form informed the students on the nature of the study, the purpose of the study, the benefits that they would derive from the study, the nature of their respective participation in the study. Their consent to participate in the study was secured. The students were also assured on the confidentiality of their identity, and that the data were used purely for research purpose.

Towards the end of the semester, the students were made to answer the Inquiry Skills Test. They were also requested to assess their Laboratory Behavior during the Chemistry Laboratory Activities. Behavior Casual interview was also conducted with the students. Casual observations were also done during laboratory sessions in order to provide further insights for the study.

The data were treated with the mean, standard deviation and Pearson Product Moment Correlation at 0.05 confidence level.

PRESENTATION AND ANALYSIS OF DATA

The data in Table 1 reveals that the students were at all times directly involved in active observation, conversation and listening during the laboratory activity. At all times, they moved around the laboratory, which facilitate the lessons. They wrote data and recorded observations at all times in the laboratory during the activity. Moreover, the students actively listened and received information from the teacher and from their classmates at all times.

However, the data show that sometimes, the students transmitted and conveyed information without manipulation of laboratory equipment and apparatus. Sometimes, the students were engaged in some interactive and non-interactive behaviors which were not directly related to the lesson, like doing assignments from their other classes also manipulating their cell phones or discussing non-lesson related topics. Nonetheless, the students were generally engaged in active behaviors during laboratory activity in Chemistry.

As observed, the students were often arranged to perform their laboratory in groups. This is due to limited laboratory equipment and apparatus. Students normally work in groups in their laboratory activities because they need to share equipment, materials and think together to solve encountered problems. The students were actively engaged with the laboratory activities. Consequently, the laboratory activity in Chemistry class may possess inherent task interdependence, which is essential characteristic to implement a cooperative structure to develop inquiry skills in science.

Table 1
Laboratory Behavior Strategies in Chemistry of College Students

Laboratory Behavior Strategies	Mean	Standard Deviation	Qualitative Description
Active observation, listening to conversation where the student is directly involved	2.81	1.22	Always
Moving around the laboratory with a purpose; other mobile activities which facilitate the lesson	2.72	1.92	Always
Writing/ recording data and other information related to lessons in the laboratory	2.71	1.92	Always
Reading lesson/ notes by another student, a textbook, a laboratory manual	2.70	1.79	Always
Passive listening, receiving information from the teacher, classmates in the laboratory	2.69	1.60	Always
Experimenting, manipulating equipment; observing experiment and other lesson-related activities	2.58	1.41	Often
Showing, demonstrating materials to transmit information to teachers and class classmates	2.50	1.89	Often
Gathering information and asking questions from the teacher and classmates	2.41	1.87	Often
Giving, transmitting, conveying information without manipulating	2.19	1.89	Occasionally
Behavior which does not facilitate the goals of the lesson including interactive and non-interactive behavior	1.73	3.12	Occasionally
Overall	2.50	2.12	Always

It is noteworthy from the findings that there was integration of laboratory activities with non-laboratory and theoretical concepts taken up in class. Nevertheless, there was still a need to find model of teaching that could facilitate student interaction with their lesson, with their classmates and with their teacher as well. If the students learn in variety of ways and come to their Chemistry class with entry knowledge, there is a need for the Chemistry teacher to respond to the students with the use of variety of teaching strategy to enable the said students to intelligently interact with their classmates, with their teacher and with their lessons.

Salter and Atkins (2017) claimed that the inquiry skill is achieved when students have the greatest amount of interdependence, engaging in activities that come closest to doing real science. Scientific inquiry is an activity people engage when they do science. Guided inquiries can be used to help students make transition from laboratories in which they work like technicians to those where they work like scientists. The goal is to help the students negotiate with the complexities of scientific inquiry so that they would be able to engage in independent open inquiry as soon as they were able to do so.

Laboratory work in a science class could assist the student to understand the way of a scientist. If this statement is accepted, then there is a need to gain further information on the laboratory behavior strategies of students that are associated with their inquiry skills. This is because students could learn by doing and learn how to learn. Laboratory activities could increase their understanding of science concepts and motivate them to learn that would develop their inquiry skills.

Shown in Table 2, the students had achieved approaching proficiency with their Inquiry skills in Chemistry as shown in their scores from the Inquiry test in Chemistry. The data would show that the students had developed the fundamental knowledge and skills in the core inquiry skills in Chemistry with little guidance from the teacher and from their peers. They could transfer these understanding and skills through authentic performance.

Table 2
Inquiry Proficiency in Chemistry of College Students

Inquiry Proficiency	Mean	s. d.	Qualitative Description
Overall	11.65	3.80	Approaching Proficiency

In Table 3, the test of relationship shows low, yet significant association of the laboratory behavior strategies and inquiry skills of the students in Chemistry. It is shown that active observation, listening, direct involvement with laboratory activities as well as note taking, asking questions and other writing activities, directly related to the lesson, are associated with the students' inquiry skills. Likewise, manipulating equipment as well as observing experiments and recording data during laboratory activities could influence the students' inquiry skills.

Nevertheless, reading lesson/ notes by another student, a textbook or a laboratory manual, do not associate with the students' inquiry skills. Also, conveying, transmitting, giving information without manipulation of laboratory apparatus or equipment do not influence their inquiry skills. This would imply that students' passive engagement in their laboratory activities may not promote development of inquiry skills needed to make them good scientists. Likewise, performing "cook-book" laboratory activities and passive learning do not associate with their inquiry skills. It could be that the students were only learning scientific facts rather than the inquiry skills.

Table 3
Test of Relationship between the Laboratory Behavior of Students and their Inquiry Proficiency in Chemistry

Laboratory Behavior	Inquiry Proficiency	
	r – value	p – value
Active observation, listening to conversation where the student is directly involved	0.23	0.02*
Moving around the laboratory with a purpose; other mobile activities which facilitate the lesson	0.29	0.04*
Writing/ recording data and other information related to lessons in the laboratory	0.21	0.03*
Reading lesson/ notes by another student, a textbook, a laboratory manual	0.13	0.21
Passive listening, receiving information from the teacher, classmates in the laboratory	0.29	0.34
Experimenting, manipulating equipment; observing experiment and other lesson-related activities	0.37	0.03*
Showing, demonstrating materials to transmit information to teachers and class classmates	0.23	0.04*
Gathering information and asking questions from the teacher and classmates	0.26	0.06
Giving, transmitting, conveying information without manipulating	0.16	0.13
Behavior which does not facilitate the goals of the lesson including interactive and non-interactive behavior	0.11	0.09
Overall	0.20	0.01*

The data show that passive engagement in the Chemistry laboratory activity may not promote development of the inquiry skills. Asking questions and gathering information has low association with inquiry skills. This may not suggest that the said students are not to be hindered to ask questions. They are to be given ample opportunity to question and seek clarification about procedures during laboratory activity in order to enable the students to go beyond "cook-book like" laboratory activities.

GENERAL FINDINGS

Generally, the findings in this study show that laboratory behavior strategies have low association with their inquiry skills. This could mean that other behavior strategies not described and measured in present investigation, are associated with the development of the inquiry skills and other habits of good scientists. It appears that student are grouped and interacted with each other in the Laboratory activities because they have to share with each other the laboratory equipment, materials and apparatus. Even though that the students most of the time observe, write, listen and discuss with their classmates and with their teacher, the relationship of these behavior strategy with their inquiry skill is low.

Nevertheless, experimenting, manipulation of laboratory apparatus and observing experiments and other lesson-related activities are predictors of their inquiry skills. This support the notion that students could acquire attitude and inquiry skills as they are engaged in hands-on, task related activities (Ortiz, 1998). Practical activity enables the students to experience learning that involves hands-on and manipulation of materials that enhance learning. The students participate constructively and are involved to enhance their learning.

Reading has no relationship with the inquiry skills of the students as the finding shows. The voluminous reading could have an effect if the laboratory procedure is not clearly organized or if the students could not recast written materials into manipulation procedure (Marzano, 1992). In essence, a thorough understanding of written laboratory instructions could be the first step in conducting laboratory activity in Chemistry class.

Therefore, it would be interesting to further examine how reading behavior influence the inquiry skills and other outcome of students in the laboratory activities. Moreover, the Chemistry teacher behavior during the laboratory could also be examined as this could also influence students' learning outcome in the laboratory activities. Laboratory activity need to be appropriately organized, designed and presented.

CONCLUSIONS

The findings of the study imply that efforts to improve the effectiveness of science laboratory as an instructional technique may also need to focus on the teacher behavior and goal structure during the implementation of laboratory activities. The study provides Chemistry teachers information which laboratory behavior strategy of students associate with their inquiry skills.

With the findings, it is anticipated that the science teacher, vis a vis the Chemistry teacher will make further use of the laboratory with some consideration of the students' interaction behavior with their lessons and activities as well, with their classmates and with their teacher. The teacher's interaction behavior in the science laboratory activities may also need to be revisited as the teacher also could influence the students' classroom outcomes (cognitive, affective, and motor).

In performing laboratory activity, the most difficult part for the students is to make sense of the activities and to relate them to theoretical concepts. Hofstein, et.al (2001) claimed that meaningful learning from laboratory work seem difficult to students in Chemistry. This apparently occurs when students are supposed to integrate theories and concepts learned in

the lecture in class and also to integrate laboratory activities with those situations or situations that the students find practicable in their daily life.

With the high cost of laboratory teaching and the doubts about its effectiveness, science researchers may be encouraged to monitor students' views of their laboratory classes. Science research may further investigate the impact of laboratory environment on student outcomes, specifically on the development of students' inquiry skills, and also to provide systematic attempts to improve the learning environment.

The findings of the study point out to the need to take account of the student laboratory interaction behavior strategy as this could influence students' learning outcomes. The students' interaction behavior strategy is a variable under the control of the teacher that could influence the development of students. This view is advanced since the teacher is the main change agent in the school learning environment. Whether the science teacher, vis a vis the Chemistry teacher has the academic preparation in what is being handled, the teacher may influence students' inquiry skills development. The inquiry skills could make or remake whether the student would engage with the real work of a scientist, which is a legitimate goal of science teaching/ education.

Through laboratory activities, the students could gain some appreciation of the wonder of science, vis a vis Chemistry. Teachers of Chemistry have to reasonably expect the Chemistry students to feel the sense of wonder and excitement which is felt by professional Chemist.

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