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"Yin" in a Guided Inquiry Biology Classroom – Exploring Student Challenges and Difficulties

Jed Aries F. Castro[1], Marie Paz E. Morales[2]

[1] Jed Aries F. Castro, Philippine Science High School – Pampanga, PHILIPPINES
[2] Marie Paz E. Morales, Philippine Normal University, PHILIPPINES

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ABSTRACT

Student encountered challenges in performing guided inquiry learning (GIL) activities are a minority literature in science education, but may provide valuable inputs to developing science process skills vital to scientific literacy. This study determined the challenges and difficulties by science-oriented students in performing GIL activities in biology. Cluster sampling determined the participants in the pre-survey (69 grade 8 students) and the actual investigation (30 grade 8 students). A validated survey questionnaire pre-identified the six major difficulties of the students. Validated student and expert questionnaires assessed the level of difficulty in each of the task on the six pre-identified challenges. Results show that science-oriented students and the experts assessed the following with a fair difficulty level: background knowledge; performance of laboratory procedure; managing extended activities; designing an experiment; and writing a laboratory report. The same group assessed the task – data analysis to be "difficult." The upper (high average to superior IQ) group and lower (average to above average) groups of science oriented students provided a non-significant difference in their difficulty assessment of all the tasks. However, replicating the study to include low cognition students from non-science oriented schools may provide a wider perspective of these student-encountered difficulties and challenges in GIL.

Keywords: Challenges and difficulties, Guided Inquiry Learning, Science Process Skills, Scientific Literacy, Inquiry-based learning – 5Es

INTRODUCTION

Success in learning science may be attributed to several factors such as interest, motivation, student engagement (Beal & Stevens, 2007; Broussard & Garrsion, 2004; Johnson, 1996; Sandra, 2002; Skaalvik & Skaalvik, 2006; Zhu & Leung, 2011) and content knowledge (Cavallo, Rozman, Blinkenstaff, & Walker, 2003). Ultimately, this success is gauged on students' scientific literacy which has been one of the major global goals of science education which countries aspire to achieve (Australian Council for Educational Research, 2014; Fensham, 1985; Hobson, 2006; Tan, 2004). Like any other country, the Philippines push forth to achieve a scientifically and technologically literate country. To promote scientific literacy to the students and the society, Anderson (2002), and Ozdemir and Isik (2015) found

Corresponding author e-mail: morales.mpe@pnu.edu.ph

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scientific inquiry as a vital approach and science process skills are the important part of it. Thus, it becomes significant to look into inquiry learning and process of assimilating science process skills.

Inquiry-Based Learning

Inquiry-based learning (IBL), as described by Beyer (1979) is a promising method for developing deep understanding of science concepts and content. Literature (Bybee, 2002; Siebert & Macintosh, 2001; Wilke & Strait, 2005; Aktamis, Higde, & Ozden, 2016) indicate that deeper learning occurs when students are more actively engaged in the process. This learning occurs when students explore authentic problems using tools and skills of the discipline and which requires more active student participation and higher order thinking skills. Accordingly, it is a learning framework that activates student engagement to develop a full range of scientific skills. Apparently, Leach and Scott (2002, 2003) tracked its success with the original five-step inquiry process by Beyer as: 1) define a problem; 2) develop a hypothesis; 3) search for evidence; 4) draw a conclusion; and 5) test the adequacy of the conclusion. Students engaged in these steps may develop science concepts and scientific process skills—features and capabilities of IBL that helped strengthen the science education of HongKong Education Bureau (EDB, 2008) to promote student's scientific thinking. The same IBL features propelled the Philippine science education community to adopt the approach to its K-12 program to develop scientific literacy among its students. Colburn (2000) categorized inquiry based learning in three approaches: structured, guided, and open inquiry itemized in ascending order of the learner's autonomy over the setting investigation problem and planning problem-solving procedures. Significant distinctions between these approaches distinguished the amount of scaffolding and the level of independence given to the learner. Healey and Jenkins (2009, p.72) believed that guided and open inquiry are necessary to build motivation then structured inquiry may be used to further develop students' research skills. Several research findings (Hakkarainen, 2003; Marshall et al., 2009; Song & Looi, 2012) suggest that guided inquiry approach is especially suitable for young learners, as teachers are able to match the level of investigation and scaffolding with the learners' ability. Moscovici (2003) confirmed this suggestion that guided inquiry learning are appropriate for middle school and high school students.

Inquiry-guided learning or guided inquiry-based learning according to Green (2003) promotes classroom practices that help students improve, sharpen, and follow through their own questions, and develop a habitual sense of inquiry. In several related studies, researchers (Cooper, 2014; Green, 2003; Farell, Moog & Spencer, 1999; Jin & Bierma, 2011; Repinc & Juznic, 2013; Aktamis, Higde, & Ozden, 2016) documented guided inquiry's success in bringing students to engage in learning and to learn science concepts in deep ways. Roles are eminent in guided inquiry learning. Lee (2011) reports that guided inquiry worked best with the following sequence: K-presentation of knowledge/content; i1 and i2 – guided inquiry skill development; I – inquiry; i3 and i4 – guided inquiry skill development; and so on. Success of guided inquiry learning correlates to Kulhthau, Maniotes, and Caspari's (2012 p.33) concept of student engagement on their "third space," in which students make connections to their real world and where the learning is applicable to it immediately.

Challenges and Difficulties in Guided Inquiry Learning

However, though researchers (Krajcik et al., 1998; Kong & Song; 2014; Song & Looi, 2012; Yeo & Tan, 2010; Aktamis, Higde, & Ozden, 2016) agree that inquiry learning may bring about the best in students, other researchers (Brown et al., 2006; Spencer, 2006) identified several limitations of inquiry learning. These were the same findings reported by

Mohamed (2008) and Rajan and Marcus (2009) who retold that students dislike inquiry learning when first exposed to the method as they feel unequipped to do the tasks. Teachers also find inquiry learning time consuming (Nidup & Yodyingyong, 2015), thus, resulting to economizing on the number of topics covered.

Edelson, Gordin, and Pea (1999) identified the most significant challenges to the successful implementation of inquiry-based learning: motivation; accessibility of investigation techniques; background knowledge; management of extended activities; and practical constraints of the learning context. Other studies reported the following difficulties and challenges: slow process, handling of laboratory apparatus and its uses, observation skills, fear of handling chemicals and glass wares (Nidup & Yodyingyong, 2015); incapability of using tools, inability to design their experiment, and comprehend terms such as hypothesis, variables and data collection (Pewnima, Ketpichainaronga, Panijpanb, & Ruenwongsaa, (2011); and difficulty in searching and organizing information (Rola, Abrantes & Gomes, 2004). These challenges in inquiry learning implementation may have hindered several success stories for this approach. Thus, Song and Looi (2012) tried to balance the two approaches (inquiry and guided inquiry) and developed the 5E inquiry-based pedagogical model: engage, explore, explain, evaluate, and extend; which the Philippine K – 12 education program adopted to implement the science curriculum. Though there are several aforementioned literature on difficulties encountered in implementing inquiry learning, studies on difficulties and challenges attributed to guided inquiry is a minority with only Lee (2012) emerging to have conducted a study on opportunities and challenges in inquiry-guided learning in the collegiate level and not on the K – 12 program, thus, the focus of the study.

PURPOSES OF THE RESEARCH STUDY

Generally, the study aimed to identify the challenges encountered by the Grade 8 students in performing guided inquiry-based activities in Biology. Specifically, it sought to answer the question:

1. What is the level of difficulties of Grade 8 students in performing guided inquiry-based activities in Biology given the following challenges:

   a. background knowledge;
   b. performance of laboratory procedures;
   c. management of extended activities;
   d. designing an experiment;
   e. data analysis; and
   f. writing a laboratory report?

2. Is there a significant difference between the level of difficulties in each major challenge encountered by the upper and the lower groups of Grade 8 students in performing guided inquiry-based activities?

Scientific Literacy, Science Process Skills, and the 5E's

As a major goal of the Philippine education system, efforts of government agencies push forth to achieve a scientific and technologically literate country. As found, scientific inquiry is vital and science process skills are the important part of the quest towards scientific literacy. Other researchers (Akben, 2011; Aktamis & Erin, 2008; Colvill & Pattie; 2002) confirm these reports and even further postulated that activities which consist of basic and integrated process skills are its dimensions. Process skills are transferable intellectual skills, suitable to all scientific endeavors. Accordingly, the American Association for the

Advancement of Science (AAAS, 1998) identified these 14 science process skills generally classified into two groups as basic skills and experimental or integrated skills.

The 5E Instructional model used by Song and Looi (2012) to balance inquiry and guided inquiry learning was developed in 1987 by the Biological Science Curriculum Study (BSCS) led by Roger Bybee. This 5E's, consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation. BSCS (2006) defined each phase with specific function and which contributes to the teacher's coherent instruction and to the learners' formulation of a better understanding of scientific and technological knowledge, attitudes, and skills. Researchers (Oszevgec, 2006; Ergin, Kanli, & Unsal, 2008) explored the effectiveness of the students' materials developed using the 5E model on their achievement and attitudes. However, a majority of investigations in GIL relates the approach to acquiring skills and better student achievement and a minority for difficulties and challenges encountered by students in implementing GIL. Thus, the study focuses on challenges rather than success, to contribute to the existing literature on GIL, process approach, and scientific literacy.

METHODS

Research Design and Participants

Cross-sectional survey collected information from a sample drawn from a pre-determined population. Randomly selected 69 Grade 8 student-participants answered the pre-survey questionnaire to initially identify the major challenges of the students in guided inquiry based activities prior to implementation. Three content experts validated (descriptively and quantitatively) and evaluated the questionnaires for both the teachers and the students. Aiken's content validity coefficient determined the content validity indices of the major instruments of the study. Ten students randomly selected from the initial set of (69) participated in the pilot administration to establish reliability (descriptive) of the major research instruments used.

Thirty Grade 8 students with age range of 13 to 15 years identified through cluster sampling technique comprised the sample of the study. Sixty percent were males and 40% are females. They were pre-grouped through random group assignment to form 6 heterogeneous sets. Within the groups, tagging identified those students belonging to the upper group (U-with Very Superior/Superior/High Average IQ) and the lower group (L-with Above Average/Average).

Research Instruments

Pre-survey Questionnaire

This instrument is a validated researcher-designed pre-survey questionnaire on the major student challenges (background knowledge, access to resources, performance of laboratory procedures, motivation, management of extended activities, designing an experiment, identifying variables, formulating hypothesis, data collection, analysis of data, and writing the laboratory report) in performing inquiry-based activities in their previous Integrated Science class. This instrument includes a major item on ranking the entire pre-identified and literature-based student encountered challenges students in conducting inquiry activities (Appendix A). The validation process included only a descriptive validation by content experts due to the simplicity of the questionnaire structure.

Activity Guides

These set of activities included contextualized and customized guided inquiry (GI) activities with instructions for students and major questions that directed their research activities. These GI activities are problem based learning-influenced activities that highlight in their structure the "background" that placed the context of activity and the "question" that sets the student into thinking about the solution (hypothesis) to a presented real-life problem. Students are also provided directions so as to determine how to: 1) test the hypothesis, 2) analyze data, and 3) conclude and apply. Appendix B shows a sample of the GI activity. Content experts validated all activities in terms of content and structure with an overall Aiken's content validity coefficient (VK=.933□1) interpreted as content valid (Aiken, 1985).

Questionnaire for the Students

A validated researcher-designed instrument with 12 open-ended questions used to gather data on the difficulties encountered by the students in performing the inquiry-based activities limited to the pre-identified challenges. This instrument included probing questions that may deduce very informative qualitative data on student encountered challenges in all the phases of the GI. Aiken's validity coefficient for this instrument (VK = .91 □ 1.0) is suggestive of a high validity coefficient (Aiken, 1985), which means that all experts found the contents of all the activity as valid.

Questionnaire for the Experts

This instrument is a validated researcher-designed instrument used by the experts in assessing the difficulties/challenges encountered by the students in performing certain aspects of the inquiry-based activities. This instrument includes both a Likert scale section which emphasize the six pre-surveyed student encountered challenges with several major indicators per surveyed challenge and an open-ended section where the evaluators may provide descriptive comments. Aiken's validity coefficient for this instrument (VK =.92 □ 1.0) is suggestive of a high validity coefficient (Aiken, 1985), which means that all experts found the contents of all the activity as valid.

Data Collection

Stage 1: Preliminary

The pre-survey questionnaire identified the major challenges of the students in performing guided-inquiry investigations based on their prior experiences. The students ranked each challenge based on their perception as to which is the most challenging and the least challenging. Local contextualization modified readily available activities customized to the local traditions and materials, and to the prescribed learning competencies by the Philippine Science High Schools system – the locale of the study.

At least three identified experts validated all research instruments in terms of correctness and accuracy of the content and structure of the instruments in this study. Interviews and consultations with these experts established the reliability of the activity guides. In consonance with the study of Morales (2014), ten randomly selected Grade 8 students identified terms in the texts which for them are difficult to understand to improve the readability of the instrument prior to implementation.

Stage 2: Data Collection

The conduct of the activities was facilitated with invited superiors from the same science high school to monitor and supervise the guided-inquiry implementation. The participants accomplished the four inquiry –guided activities for the whole quarter. They worked in small pre-determined groups in a flexible learning system for them to have extended activities (conducted beyond the regular sessions). After completing the four activities, they submitted group written output and individual written output. The outputs and actual observations provided the experts the data necessary to assess the challenges or difficulties encountered by the students in the pre-determined challenges of inquiry-based learning.

After performing all the activities, the researcher-designed questionnaire administered to students partially determined the specific difficulties the students encountered in terms of the major challenges in performing inquiry-based activities. The identified experts assessed student output, specifically the laboratory reports and actual observations to identify student difficulties in conducting guided-inquiry based activities. Interviews clarified which task did they encounter difficulty and provided rich qualitative data on the differences in the level of difficulty of the different tasks. Interviews with experts verified their quantitative assessments of student difficulties and challenges.

Data Analysis

In the pre-survey, each rank carries the same equivalent point as follows: rank 1, scores a point; rank 2 scores, 2 points, etc. The calculated and ranked sums of ranks for each challenge provided the upper six challenges with the least sum of ranks as the major challenges of the students. In the implementation of GI activities, the Likert scale identified, quantified, and interpreted the specific difficulties and challenges of the students on the different aspects of inquiry-based activities. Independent samples t-test established the significant difference in the challenges encountered (determined through the Likert scale instrument) by the two groups (upper and lower) of participants. Consolidated data analysis triangulated the difficulties identified by the students, assessed by experts and thematic groupings of open responses.

FINDINGS and DISCUSSION

The study sought to explore student challenges and difficulties in conducting guided inquiry learning activities. The pre-survey conducted identified hierarchically (according to rank) six major challenges of the students in performing guided inquiry based activities in Biology as: 1) writing the laboratory report; 2) designing an experiment; 3) management of extended activities; 4) analysis of data; 5) performance of laboratory procedures; and 6) background knowledge. These six major challenges were the identified fairly to very difficult (Edelson, Gordin, & Pea, 1999; Nidup & Yodyingyong, 2015; Pewnima, Ketpichainaronga, Panijpanb, & Ruenwongsaa, 2011; Rola, Abrantes & Gomes, 2004).

Student Challenges and Difficulties in Guided Inquiry Learning (GIL) Activities in Biology

In this study, Table 1 presents the six major challenges in a procedural sequence in conducting GIL activities.

Table 1. *Challenges and difficulties of students implementing GIL activities*

Difficulties	Topics	Mean	SD	Interpretation
Background Knowledge	Population density and species richness	3.38	0.77	Fairly Difficult
	Factors that limit population growth	3.43	0.62	Fairly Difficult
	Ecological interactions	2.97	0.98	Fairly Difficult
	Air pollution and acid rain	3.04	0.84	Fairly Difficult
Performing Laboratory Procedures	Measuring mass	3.00	0.10	Fairly Difficult
	Measuring temperature	3.18	0.23	Fairly Difficult
	Measuring volume	2.70	0.37	Fairly Difficult
	Measuring length	3.63	0.23	Not Difficult

	Measuring area	3.05	0.50	Fairly Difficult
	Constructing ecological quadrat	3.60	0.26	Not Difficult
	Measuring the acidity of a solution	3.73	0.20	Not Difficult
	Using the microscope	2.03	0.37	Difficult
Management of Extended Activities	Conducting a group meeting for planning	3.17	0.76	Fairly Difficult
	Conducting a literature search for the investigation	3.22	0.69	Fairly Difficult
	Preparing the materials for the investigation	3.11	0.84	Fairly Difficult
Designing an Experiment	The students are able to design an experiment that can answer research questions	2.57	0.39	Fairly Difficult
	The students are able to design an experiment that contains appropriate and specific materials	2.72	0.28	Fairly Difficult
	The students are able to design an experiment that contains logical and realistic procedure	2.67	0.39	Fairly Difficult
	The students are able to design an experiment that contains variables/elements	2.70	0.19	Fairly Difficult
Analyzing Data	The students are able to present their data logically and appropriately	2.48	0.33	Difficult
	The students are able to analyze their data that directly address/ answer the research questions	2.61	0.28	Fairly Difficult
	The students are able to interpret their data accurately and appropriately	2.39	0.20	Difficult
Writing Laboratory Report	***The students are able to write a report that…***			
	• contains specific and directly related to the subject being investigated objectives	3.09	0.69	Fairly Difficult
	• contains accurate and well-written theoretical background related to the subject being investigated	2.89	0.91	Fairly Difficult
	• contains well-written methodology of the experiment	2.82	0.25	Fairly Difficult
	• contains properly labeled graphs/tables/chart	2.59	0.26	Fairly Difficult
	• contains well-written conclusion and recommendation	2.48	0.25	Difficult
	• free from typographical errors and neatly written	3.18	0.38	Fairly Difficult
	• free from grammatical error	3.22	0.40	Fairly Difficult

Generally, as rated by experts, the participants perceived the skills related to the conduct of GIL activities, presented in Table 1, as fairly difficult. It may be inferred that these students have a good understanding of the topics related to the GIL activities which may be sourced from students' profile. Their IQ ranges from average to very superior interpreted as possessing the capacity to acquire new learning and skills with proper guidance to being very quick-witted (Culture Fair Intelligence, 2000). They even rated as "non-difficult," the three items in performing laboratory procedures (measuring length, constructing ecological quadrat, and measuring the acidity of a solution), but contradicts with their perception of difficulty in the aforementioned skills as expressed in their interview responses (e.g. "The most challenging is the quadrat sampling because it is hard to choose a random spot and count grasses and random organisms seem to have an infinite number."). This contrasting result may imply that there are certain difficulties students encounter in conducting GIL activities as: handling laboratory apparatus and its uses, fear of chemical and fragility of glass apparatus (Nidup & Yodyingyong, 2015); researching information (Rola, Abrantes, &Gomes, 2009); identifying treatment, outcome, and control variables (Dasgupta, Anderson, & Pelaez, 2014); and comprehending hypothesis, variables, and data collection(Pewnima, Ketpichainaronga, Panijpanb, & Ruenwongsaa, 2009).

Consequently, experts assessed most of the "difficult" rating in analyzing data and writing laboratory reports. Specifically, they considered the following as difficult: 1) present their data logically and appropriately; 2) interpret their data accurately and appropriately; and 3) well-written conclusions and recommendations as difficult and challenging for the students. These results accord with the responses of the students for the specific challenges they encountered in analyzing their data. Their responses are as follows:

"Analyzing the data is hard. Understanding them and relating them to your background is hard because maybe limitations of the experiments."

"Writing the conclusion because it is very hard to conclude if an experiment failed."

It seems that these students find the analysis of the data task as most challenging probably because presenting and analyzing data in a more structured way is more familiar to them. Dasgupta, Anderson, and Pelaez (2014) reported the same results that middle school students have trouble interpreting findings when faced with natural variation. Also, their encountered difficulty ranges from writing the introduction and putting emphasis on difficulty in presenting their results to writing the conclusions, usually encountered when students shift from rhetoric writing to academic writing. Martin (1990), Neville (1996), Hocking (1995) and O'Toole (1994) reported the same key issue when a learner commences as university students and shifts from literary writing to scientific writing.

Comparing the Expert' Assessed Challenges of Upper and Lower Groups

Comparing experts' assessments of the groups in performing guided inquiry learning activities may provide inferences on which challenges are dominant in which set of students. Table 2 presents the comparison of expert assessed challenges of the upper group and the lower group of all the heterogeneous clusters.

Table 2. *Comparing Upper and Lower groups' expert assessed challenges*

Challenge	Group	Mean	Standard Deviation	Mean Difference	Df	t-statistics	p-value
Background Knowledge	U	3.20*	.27	.01	28.00	.11	.91
	L	3.21*	.30				
Performance of Laboratory Procedures	U	3.29*	.21	-.13	28.00	1.67	.11
	L	3.16*	.23				
Management of Extended Activities	U	3.21*	.47	-.09	28.00	.57	.57
	L	3.12*	.31				
Designing an Experiment	U	2.61*	.46	.12	28.00	.66	.52
	L	2.73*	.51				
Data Analysis	U	2.43**	.42	.14	28.00	.95	.35
	L	2.57*	.35				
Writing the Laboratory Report	U	2.93*	.33	.07	28.00	.69	.50

L-Lower group, U-Upper group **Not Difficult, **Fairly Difficult* ****Difficult*

In five out of six challenges (background knowledge, performance of laboratory procedures, management of extended activities, designing an experiment and writing the laboratory report) experts assessed the challenges encountered by both groups as fairly difficult. Though there are minute differences in the means of the upper and lower groups, these differences are not significant ($p>.05$). The challenge encountered by the student in analyzing data, assessed by experts as difficult for the upper group and fairly difficult for the lower group also incurred a non-significant mean difference ($p>.05$). It may be inferred from these results that differences in IQ levels of students do not provide differences in the student encountered challenges and difficulty in performing guided inquiry learning activities. Thus, chances that both groups of students will perform well if these difficulties are addressed are not imaginary ideas. The idea confirms Konikova's (2016) findings that IQ does not predominantly predict success, achievement and performance of students, but student motivation now plays a significant role in student success.

CONCLUSİONS

As the Chinese proverb goes, "The gem cannot be polished without friction, nor man perfected without challenges." Difficulties usually surface in all human activity, even in the teaching-learning process. Thus, teaching and learning practices should focus on two tracks – attaining student achievement and addressing student difficulties. This teaching and learning principle does not only apply to select learning areas, but also perfectly fits learning science. Learning science in the new curriculum is not limited to applying inquiry learning for students to attain student achievement and inculcate scientific literacy. It also highlights using the best possible method of inquiry (guided inquiry learning [GIL]) appropriate to the needs of the learner and learner's developmental maturity to motivate the students to engage in science and encounter success and difficulties as well. Focusing on these student experiences may bring about the desired outcome – student engagement, complete assimilation of content and process skills and scientific and technological literacy. The majority of literature (Cooper, 2014; Green, 2003; Johnson, 2011; Jin & Bierma, 2011; Kam & Hoop, 2013), report the success of GIL in attaining student achievement. However, challenges and difficulties encountered by students in performing GIL activities are minority literature and must also be emphasized together with studies on using GIL as an approach to better the achievement of students if one needs to attain complete understanding of science concepts and scientific methods and processes of science. Understanding the difficulties and challenges encountered by students is like the principle of Taoism – you cannot attain the complete concept of inquiry learning and science process skills by only taking a look at the approach in terms of student achievement. You also need to see the other side of the coin—difficulties that may be addressed to further propel achievement of scientific literacy. This principle of learning is similarly projected by Grilley (2007) who described Toaists concept of "opposites define each other." She explained that the very words used to describe things are meaningless without their opposites. Words such as big, bright and hot are strongly defined by their opposites small, dark and cold. Toaists labeled this principle as yin and yang. The yin yang theory is a kind of logic that connects things in relation to their whole (Shen-Nong, 2005) and a concept of duality forming a whole (Kochmer, 2016). Thus, in the concept of learning science, emphasizing achievement is one, and addressing difficulties completes the whole learning process. It is the idea that difficulty defines student achievement in science and that which propels students to achieve further, while this attained achievement drives more force for students to struggle and attain enhanced learning.

On challenges and difficulties

Challenges and difficulties identified in this study may provide a significance to teaching and learning processes of science concept geared towards scientific literacy enhancement. These specific challenges may offer ideas for teachers and researchers on how to plan the curriculum and instructional materials to address these difficulties and challenges. The non-significant difference in challenges of the upper and lower group as assessed by experts may be an indication that even the good ones in terms of cognitive human faculty encounter the same difficulties and challenges as those assessed with lower cognition. Thus, cognitive processing may be different between the lower and the upper groups, but we can improve their achievement by addressing their difficulties. Finally, the results of this research may provide both practitioners and researchers; two views and perspectives in terms of Guided Inquiry Learning – that focused on using the approach for better attitude and achievement (the yang) and that which emphasize the challenges and difficulties (the yin) for the complete grasp of teaching and learning of science process skills.

Suggestions

Only one science-oriented (Philippine Science High School) campus participated in this study; thus, future studies could use the same framework to extend the work to all science-oriented and non-science oriented high schools in the Philippines. Curriculum designers could develop instructional materials to address the identified student-encountered difficulties and challenges. They may also incorporate localized GIL activities to instil sustainability of the

Filipino indigenous practices and traditions while mastering science process skills and developing scientific literacy.

For more encompassing outcome, a longitudinal research may be done to expand data gathering and analysis as much as explore the learning and teaching aspects of science concepts that would apply a triangulation of the three domains of education: cognitive, affective, and psychomotor. Learners' evolution in all these domains of learning would be supervised and harmonized with the different stages of their psychological development. A series of professional development program on conducting and implementing GIL activities inclusive of disseminating student-identified challenges may be launched for the experimental process on the teaching aspect and as capability building for better delivery of science knowledge to our most valued clientele – students.

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Appendix A
Pre-survey Questionnaire for the Students

NAME (optional): ____
SECTION: ____

DIRECTIONS: The following items are challenges that you may have encountered as you perform the different inquiry-based activities. Rank them from 1 to 11. 1 being the most challenging and 11 being the least challenging.

Rank	**Challenge**
	Background Knowledge
	Access to Resources
	Performance of Laboratory Procedures
	Motivation
	Management of Extended Activities
	Designing an Experiment
	Identifying Variables
	Formulating Hypothesis
	Data Collection/Presentation
	Data Analysis
	Writing a Laboratory Report

Appendix B
Sample Guided Inquiry Based Activity

QUADRAT SAMPLING/BIODIVERSITY

Background

Biodiversity is defined as the total variety of life on Earth. Species diversity refers to the different species in an ecosystem. It is sometimes called species richness. For example, there are five different species of plants in Area A and two in Area B. Thus, Area A is richer than Area B in terms of species.

Another important data that is being collected by ecologists in conducting ecological study is the population density of different species of organisms. It is calculated using the formula below:

$$\text{density} = \frac{\textit{number of plants or animals}}{\textit{area occupied}}$$

In conducting an ecological study, as it would be challenging to account for all the different organisms especially if the field of study is wide, sampling quadrats are used. An ecological quadrat is basically plot to isolate a standard unit of the study area. The data that will be gathered from these quadrats will represent the entire area of study. The sample quadrat is shown in Figure 1. It is typically 1 square meter in dimension.

In this activity, you will compare the species richness of plants and animals in two different areas in the school. In addition, you will account for the population density of plants in your chosen area of study. You will survey small areas within each ecosystem using a quadrat similar to the one shown in Figure 1. Finally, you will calculate the diversity index of your study area using the Simpson's Diversity Index formula below.

$$D = 1 - \sum \left(\frac{n}{N}\right)^2$$

where:
D = diversity index
n = the number of individuals of a particular species
N = the total number of individuals

The value of ***D*** ranges from 0 to 1, with 1 representing infinite diversity and 0, no diversity.

Figure 1. Sample Quadrat

You may choose to compare any two areas in the vicinity of the campus. Examples include the grassy area near the entrance gate, nature's park, the small pond, and the garden.

Question
Which area in school has a higher number of species of plants and animals?
How does population density of local plants differ between the two selected areas in the school?

Form a Hypothesis
Recall your knowledge about ecosystem, community, population, and biodiversity. Write a hypothesis in your science journal.

Test Your Hypothesis

1. Think of a way on how to test your hypothesis. You may use textbooks or online resources in planning your investigation. Consider the materials that you will use. How will you test your hypothesis?

2. Write in your science journal the procedure that you are planning to implement. Decide which two areas in the school you will consider in doing your investigation. Then, you will have to construct your quadrat (Use 5 quadrats/areas.). After deciding on the communities within the school premises, think of a way on how to ensure that the small areas (quadrats) within these communities are randomly selected.

3. Once you are ready to conduct your survey, consider the following questions:
   If you are planning to sample soil or water in your investigation, how will you do it?
   In accounting for the diversity of plants and animals, how will you identify them? (For this class, if identifying their common names is challenging, you may refer to them as Plant A, Plant B, etc.).

   How will you describe other details about the area surveyed? Will you make a map to show the distribution of the plants/animals in your study area?
   How do you plan to record and present your data?

What safety precautions do you need to take note of before conducting the activity?

4. Submit your detailed plan to your teacher. Write it on your science journal.

5. Implement your approved plans. Take careful notes as you conduct your surveys. Think of an appropriate way to present your data (table, graph, etc). What will you do to these data to answer your research questions?

Interpret Your Data

1. Calculate the population density of the plants/animals you are studying.
2. Calculate the species richness in your areas of study.
3. Compare values of population density for the two areas that you surveyed. In which area are the plants denser? Do your data support your hypothesis? Explain why or why not.
4. Compare and contrast the characteristics of the two ecosystems that you studied. How are the characteristics of each ecosystem related to the species richness? What could have been the factors for it to be more diverse?

Conclude and Apply

1. Compare your data with those of others in the class. Take note of the similarities and differences in the data. What conclusion can be made from these data?

Important Notes:

1. In planning your investigation, consider the available resources in the laboratory/school. You may also consider bringing materials from your house to conduct the investigation.
2. Set-ups must only be done in school. You are expected to submit a laboratory report on your findings.
3. Prepare a Material Safety Data Sheet for every activity.

Suggested Reading Materials:

1. http://www.dartmouth.edu/~bio21/exercises/Sampling.handout.pdf
2. Miller, K., et.al. (2008). Prentice Hall Biology. Boston Massachusetts. Pearson Education, Inc.
3. Biggs, A., et.al. (2008). Glencoe Science Biology. USA. McGraw-Hill Companies, Inc.
4. http://geographyfieldwork.com/SimpsonsDiversityIndex.htm