Addressing the Challenges and Scaffolding of Inquiry-Based Teaching on Secondary School Students' Efficacy in Conducting Scientific Inquiry

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Abstract Anderson (J Sci Teach Educ 13(1):1–12, 2002) raised several questions about inquiry in terms of meaning, emphasis, approach, teaching, and learning among others. However, the question on barriers in initiation and implementation offers few answers in literature. Likewise, despite several attempts to explicate scientific inquiry, few studies delve on the process of scientific inquiry as a practice. It is observed that different schools have different approaches as a practice on how scientific inquiry is implemented. This chapter presents the practice of scientific inquiry at Philippine Science High School Western Visayas Campus. Likewise, the chapter highlights the entire curriculum for programs where scientific inquiry can be practiced. However, this chapter tackles only the implementation of its Science Internship and Science Research programs. It presents the barriers to its implementation and how these barriers were addressed. Examples of successful practices are presented as type study which led to students to publish their paper to peer-reviewed journals. The chapter concludes with insights and lessons on how scientific inquiry can be successfully practiced in classrooms all over the world. Lastly, an implication of school's practice on scientific inquiry, science education, inquiry learning and teaching is also presented.

1 Introduction

The science education literature generally supports inquiry-based instruction. In fact, most countries' science curriculum requires it. This causes numerous definitions of inquiry to exist in the literature. The term "scientific inquiry" is prevalent in the United States while "science investigation" is widely used in the United Kingdom, Australia, and New Zealand (Moeed, 2013). In this chapter, "inquiry" is favored as a more encompassing terminology.

For the meaning of inquiry, most researchers and educators rely on a functional definition of inquiry, in which emphasis is given to the role of the learner's control

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over the activity (Minner, Levy, & Century, 2010). This would sometimes lessen the teacher's direct control of the activity, thus only being the facilitator of learning. Leaving out the teacher prevents us from seeing the whole picture of inquiry. This chapter provides a more holistic point of view and enriches the role of inquiry facilitators.

Anderson (2002) pointed out that in addition to the meaning of inquiry, other issues are important: emphasis in, approaches to, the teaching of, and students learning inquiry. Inquiry's emphases are being questioned: for example, who provides the research question and determines other inquiry tasks, the teacher or student? Ryker and McConnell (2014) tabulated the various possibilities and levels of inquiry determined by who controls each characteristic (see Table 1). According to these researchers, provision or non-provision is a matter of teacher's choice, which is highly based on a teacher's positionality. Positionality may be considered to be attitudes and beliefs about inquiry in classrooms. Unless inquiry is required and clarified by the curriculum, a teacher is forced to implement inquiry-based teaching methods without explicit guidance concerning the intended approaches (Center for Science, Mathematics, and Engineering Education, 2000).

The approach to inquiry as used in this study is synonymous to process. Warner and Myers (2008) emphasized that teachers play a vital role in adapting the inquiry process to the knowledge and ability level of their students. According to the Center for Science, Mathematics, and Engineering Education (1995), inquiry approach on the part of the students involves students undergoing the following five basic steps: (1) question; (2) investigate; (3) use evidence to describe, explain, and predict; (4) connect evidence to knowledge; and (5) share findings.

Table 1 Characteristics and levels of inquiry determined by the teacher's control versus the student's control

Characteristic	Level 0: Confirmation	Level ½: Structured	Level 1: Guided	Level 2: Open	Level 3: Authentic
Problem/Question	Provided	Provided	Provided	Provided	Not provided
Theory/background	Provided	Provided	Provided	Provided	Not provided
Procedures/design	Provided	Provided	Provided	Not provided	Not provided
Results analysis	Provided	Provided	Not provided	Not provided	Not provided
Results communication	Provided	Not provided	Not provided	Not provided	Not provided
Conclusion	Provided	Not provided	Not Provided	Not provided	Not provided

Note Adapted from Ryker and McConnell (2014)

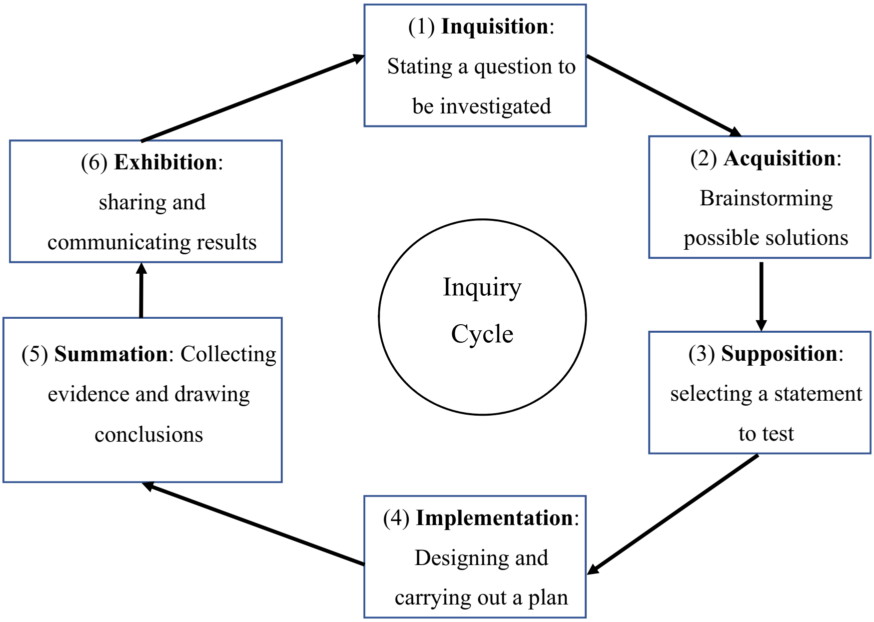

Fig. 1 The inquiry cycle

Llewellyn (2002), however, would consider inquiry approach as a cycle. The cycle includes: (1) Inquisition—stating a "what if" or "I wonder" question to be investigated; (2) Acquisition—brainstorming possible procedures; (3) Supposition—identifying an "I think" statement to test; (4) Implementation—designing and carrying out a plan; (5) Summation—collecting evidence and drawing conclusions; and (6) Exhibition—sharing and communication results (see Fig. 1).

One thing is clear, the approach in inquiry involves both the learner and the teacher as a facilitator of learning. As for the teacher inquiry approach, it may involve: (1) starting the inquiry process; (2) promoting student dialog; (3) transitioning between small groups and classroom discussions; (4) intervening to clear misconceptions or develop students' understanding of content material; (5) modeling scientific procedures and attitudes; and (6) utilizing student experiences to create new content knowledge (Warner & Myers, 2008). One thing is clear that the approach in inquiry involves both the students as learner and the teacher as facilitator of inquiry learning. Therefore, the teaching and/or learning of inquiry must be viewed from both the teacher's and the learner's perspective.

However, most researchers investigate the students' perspective only, while a few investigate the teacher's perspective. Likewise, research on teachers' inquiry is more extensive for pre-service than for in-service teachers (Graves & Rutherford, 2012). With the scarcity in the literature of research among in-service teachers, the question of barriers to initiation and implementation of inquiry science teaching offers few answers in the literature.

Lastly, the Center for Science, Mathematics, and Engineering Education (2000) published *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. It discusses two tenets on science inquiry. The first states that educators need evidence drawn from research to help them implement and justify inquiry-based approaches to teaching and learning science. The second tenet states that one of the best ways to understand school science as inquiry is to visit a classroom where scientific inquiry is practiced. Inquiry-based science education produces positive results, yet in classrooms that conduct inquiry, teachers are frustrated, and they encounter difficult problems in implementing inquiry teaching (Anderson, 2002).

This chapter chronicles the implementation of inquiry as a scientific practice in a school by presenting a case of inquiry-based science education.

2 Context of a School-Based Implementation of Inquiry

Locale of the Study

The research study took place at the Philippine Science High School Western Visayas Campus (PSHS WVC) in Iloilo City, Philippines. The campus is one of the 16 campuses across the Philippines that operates under one system. It envisions preparing its scholars to become globally competitive Filipino scientists equipped with twenty-first century skills and imbued with the core values of truth, excellence, and service to the nation. Its mission is to provide scholarships to secondary students with high aptitudes in science and mathematics.

PSHS WVC offers scholarships (i.e., free tuition fees, free loan of textbooks, monthly stipend, uniforms, transportation, and living allowances for low income groups, and dormitory accommodation) with special emphasis on subjects pertaining to the sciences and mathematics in order to prepare its students for science and technology careers. The course offerings are divided into three: (1) Foundation Years (Grades 7–8); (2) Advancement Years (Grades 9–10); and (3) Specialization Years (Grades 11–12). Aside from academic requirements, students have to complete several non-graded subjects as a requirement for graduation.

A "Science Immersion Program" comes in many forms and may be taken in any school break after Grade 9 or Grade 10. It requires a minimum of 80 h exposure to a professional science laboratory and working with a scientist. Science Electives, such as Engineering, Agriculture, Robotics, Microbiology, and Microcontroller, are offered but they are optional. If Elective classes are taken, however, students' grade is included in a student's general weighted average mark. Lastly, SCALE which stands for Service, Creativity, Action, and Leadership Enhancement, should be complied during Specialization Years. In this non-graded requirement, students have to comply with one activity for each letter of the subject's acronym.

The school's Specialization Years has the following features: (1) Outcomes-Based—decisions on curriculum are driven by a predetermined set of student exit learning outcomes; (2) Learner-Centered—an emphasis on students doing the learning, with teachers acting as facilitators; (3) Humanistic Design—teaching and learning are based on reason and scientific methods; and (4) Focus on Higher Order Learning—outcomes target the more complex thinking skills.

A "Research Program" is the core of the inquiry teaching and learning. The country, and thus the school, have just recently adopted the K-12 program that has been running for only two school years. In the new curriculum, science inquiry is implemented in the Research subject in the second year of Advancement Years up to Specialization Years. This is due to the fact that the Research Program is a three-year program starting from Grade 10 up to Grade 12. The program expects that during Research 1, learners can produce research proposals and preliminary paper. In Research 2, learners are expected to submit a research proposal, implement, and analyze research. During the final year in Research 3, learners are expected to write and publish their research work in scientific journals published by the school.

The Research Unit implements the research program of the school. It is composed primarily of one Unit Head, 15–17 research advisers, and six research teachers. The Unit Head works hand in hand with the teachers teaching the research subject and managing work units or groups through research advisers. The number of research advisers varies according to the number of work units formed during a particular school year. The research teachers and the research advisers are the core facilitators of learning who run the research program of the school. Both have teaching and/or advising load in the Research Subject. There are nine research teachers manning the entire research program with one research teacher handling a class composed of 30 students. A total of three teachers handle one research subject. Since there are three classes for each year level, the three teachers work as a subject unit considering the team-teaching mode of subject implementation. The research teacher can handle up to six work units which may be composed of only one or up to three student researchers for every work unit. This scheme is due to the provision that students can work alone, with a partner, or as a triad. The teachers provide the classroom instruction while advisers work with students as they conduct their research.

In contrast, teachers do the input conceptually while advisers are involved in the process or the conduct of the research. As the core of the research is highly dependent on the advisers, students' grade constitutes about 60–75% of adviser's rating. The research advisers are considered experts in their respective fields. Just like research teachers, a research adviser can only take up to six work units. A corresponding 0.5 unit is given to research teacher or adviser in handling a work unit in research. Research advisers are needed to (1) encourage accomplishment of more specialized projects; (2) neutralize the tendency of students to propose research studies based on available campus expertise; (3) widen opportunities for research linkages; and (4) increase the competitiveness of PSHS researches for presentation to public audiences through publication or other means.

The PSHS Curriculum (see Fig. 2) includes eight general capabilities. These capabilities include literacy, numeracy, information and communication technology, critical and creative thinking, personal and social capability, ethical understanding,

Foundation Years						Advancement Years						Specialization Years					
Grade 7			Grade 8			Grade 9			Grade 10			Grade 11			Grade 12		
Subjects	Mtg	Unit	Subjects	Mtg	Unit	Subjects	Mtg	Unit	Subjects	Mtg	Unit	Subjects	Mtg	Unit	Subjects	Mtg	Unit
Integrated Science 1	5	1.7	Integrated Science 2	6	2.0	Biology 1	3	1	Biology 2	3	1.0	Biology 3	5	1.7	Biology 4	5	1.7
						Chemistry 1	3	1	Chemistry 2	3	1.0	Chemistry 3			Chemistry 4		
						Physics 1	3	1	Physics 2	3	1.0	Physics 3			Physics 4		
Mathematics 1	5	1.7	Mathematics 2	5	1.7	Mathematics 3	3	1	Mathematics 4	4	1.3	Mathematics 5	3	1.0	Mathematics 6	3	1.0
English 1	4	1.3	English 2	4	1.3	English 3	3	1	English 4	3	1.0	English 5	3	1.0	English 6	3	1.0
Filipino 1	3	1.0	Filipino 2	3	1.0	Filipino 3	3	1	Filipino 4	3	1.0	Filipino 5	3	1.0	Filipino 6	3	1.0
Social Science 1	3	1.0	Social Science 2	3	1.0	Social Science 3	3	1	Social Science 4	3	1.0	Social Science 5	3	1.0	Social Science 6	3	1.0
Physical Education / Health / Music (PEHM) 1	3	1.0	Physical Education / Health / Music (PEHM) 2	3	1.0	Physical Education / Health / Music (PEHM) 3	3	1	Physical Education / Health / Music (PEHM) 4	3	1.0	-	-	-	-	-	-
Values Education 1	3	0.7	Values Education 2	2	0.7	-	-	-	Science, Technology, Engineering, & Mathematics (STEM) Research 1	3	1.0	Research 2	6	2.0	Research 3	6	2.0
Art, Design, & Technology 1	3	1.0	Art, Design, & Technology 2	3	1.0	Probability & Statistics	3	1	-	-	-	Any one of the Biology 3, Chemistry 3, Physics 3, Computer Science 5, Engineering, Technology 1, Agricultural Science	5	1.7	Any one of the Biology 4, Chemistry 4, Physics 4, Computer Science 6, Engineering, Technology 2, Agricultural Science	5	1.7
Computer Science 1	3	1.0	Computer Science 2	3	1.0	Computer Science 3	3	1	Computer Science 4	3	1.0	-	-	-	-	-	-
-	-	-	Earth Science	2	0.7	-	-	-	Elective	-	-	-	-	-	-	-	-
Total	31	10.4		34	11.4		30	10		31	10.3		28	9.4		28	9.4

Fig. 2 Philippine Science High School System. (2015). The PSHS six-year curriculum subject matrix

global perspective, and scientific literacy. In the school's Student Handbook, scientific literacy means involving "scholars in acquiring and applying scientific knowledge to critically evaluate claims, issues, and problems about the natural world, and draw evidence-based conclusions. Passion for science, and positive values and dispositions such as curiosity, risk-taking, open-mindedness, resilience, collaboration, and pursuit of the truth are cultivated'. The organizing elements of this capability are: (1) Examining natural phenomena; (2) Expressing positions that are scientifically and technologically informed; (3) Planning and conducting an investigation; (4) Processing and analyzing data and information; (5) Evaluating scientific arguments, processes, and results; and (6) Communicating using scientific language in a range of mediums.

3 Science Inquiry: School/Classroom Perspective

The school's interpretation of inquiry's meaning is inspired primarily by its role to equip students with an inquiring profile[1] (see Fig. 3). Consequently, one must conduct inquiry and purposeful research. Another inspiration is the school's vision to prepare students to become scientists in the future. We share meaning with the National Science Education Standards, which defines science inquiry as: (a) the diverse ways in which scientists study the natural world, and (b) the act of proposing explanations based on the evidence derived from their work. The meaning of scientific inquiry is best summarized by Lederman (1998) as the systematic approaches used by scientists in an effort to answer their questions of interest. The meaning of science inquiry is therefore defined by the scientist and determined by the nature of the scientific problem. The scientist finds an answer to a scientific question according to the extent of their creativity and engagement with the scientific problem.

However, Anderson (2002) would point out that this definition is independent of educational processes. He lamented the lack of operational definitions of what indeed inquiry is. The school's meaning of inquiry is to mimic the scientist and inculcate an inquirer's character in learners. Learners should think and act like a scientist. The school's emphasis on inquiry, however, is an independent work. Students are the primary researchers who are driven to become like a scientist. A scientist seeks answers to questions of self-interest. The inquiry's interest is not determined by teachers. The inquiry's interest is not determined by teachers but the students' interest as the primary scientist or investigator. The teachers simply give inputs during formal classes, and advisers follow up it during research consultation. However, there is a gray area concerning to what extent students can be allowed to conduct research independently. Issues on legality, safety, ability, and other delimiting factors would prove challenging to both research advisers and advisees.

[1]A PSHS WVC scholar should be nurtured as a holistic individual and strive to become inquirers. As inquirers, they should enhance their natural desire and enthusiasm to ask questions, conduct inquiry and purposeful research, and cultivate their love for learning.

PSHS Graduate

A PSHS graduate is holistically developed, global Filipino who is well-prepared to pursue a STEM career.

Learner Profile

Inquirer * Knowledgeable * Thinker * Communicator * Open-minded * Creative & innovative * Balanced * Life-long learners * Principles * Reflective * Compassionate * Patriotic

General Capabilities

Literacy * Numeracy * ICT Capability * Creative and Critical Thinking * Personal and Social Capability * Ethical Understanding * Global Perspective * Scientific Literacy

	Content	**Skills**	**Values & Attitudes**
	Science * Mathematics * Technology * English * Filipino * Humanities * PEHM	21st Century Skills Science Inquiry Skills	Passion for Science Truth, Service, Excellence
Gr 12 Gr 11	**Specialization** Enhanced engagement in the chosen area of specialization	Service, Creativity, Action, Leadership Enhancement (**SCALE**)	Institutional Celebrations Field Trips Student Activities Competitions
Gr 10 Gr 9	**Advancement** Deepening of knowledge, skills, and values in the various disciplines that prepares scholar for their own specialized course of study	Alternative Learning Activities (**ALA**)	
Gr 8 Gr 7	**Foundation** Fundamental knowledge, skills, and values in the different content areas		

Fig. 3 An expected PSHS graduate, profile, and capabilities

The Research Unit composed of research teachers and advisers agrees that students should be given opportunity to manage all research-related work unless delimiting factors are justifiable. The Unit has to approve if a research task should be terminated or not. Kirschner, Sweller, and Clark (2006), however, claim that students do not suffer from such guidance and supervision. While their claim may be true, a clear scheme of implementation and explicit listing of responsibilities can counteract the issue.

The approach to inquiry at the school is a student-driven inquiry. Whenever possible, the student researchers do everything as if the adviser serves as the head of the science laboratory head. The research advisees, forming work units or research groups, act as research scientists under the adviser supervision. An adviser simply manages and monitors the students or the work units assigned to students. The research teachers, on the other hand, teach students about the concepts and skills in doing research.

The teaching of inquiry is a product of methods of teaching science and math. The Curriculum and Instruction Manual stipulates that lessons in these two subjects should be computer-based, integrated, application-based, internship-like, mentored, and inquiry-based. An inquiry-based instruction includes holding investigations and research. It has sometimes gone to the extent of requiring students to submit full-blown research outputs in Filipino (a language subject) and Social Science. On top of the research project in research subject, scholars are also expected to submit a full-blown research document integrated across the school's curricula; for example, in the school's Filipino language subject, and Social Science classes. In addition to the research project within the school subject of research, scholars are also expected to submit miniresearch in their chosen core subject. Research teachers, on a weekly basis, see to it that the cycle of seminar-workshop-consultation is followed by everyone.

The learning of inquiry in formal settings also undergoes the cycle of seminar-workshop-consultation. The seminar-type instruction is implemented through team teaching. Research teachers agree who will conduct a seminar on a particular research topic. Instead of a quiz, learners' understanding is assessed via a workshop on a typical research case. Teachers evaluate the outputs (i.e., a synthesis of a journal article, concept map, or standard procedure) of the workshop and require students to apply what they have learned in their respective research projects. The research adviser and the advisees would then discuss the research progress during a weekly consultation which can last for a minimum of 20 min for every work unit.

Inquiry is also learned in other subjects as well. In the core subject areas of Physics, Chemistry, and Biology, students are required to submit a modified inquiry output. A teacher may modify the inquiry by providing the problem or procedure in the conduct of an inquiry. The output is simply report-based and devoid of preliminary and terminal pages in writing research outputs. As for the other STEM subjects, inquiry is learned by doing investigations, experiments, or simple science activities.

Prior to enrollment in the research program, students are exposed to learning inquiry by engaging in a science internship. A science internship exposes students to an authentic research-based laboratory under the guidance of a scientist or an expert for a minimum of 80 h. Students complete all the research tasks agreed upon by the school and the host laboratory. During internship, students are exposed to the daily routine of a scientist as they observe or even help with some tasks assigned to them. Research tasks may be designed by the lab or simply embarking on whatever are the tasks at hand during the period of internship.

Other opportunities to learn inquiry come through science workshops and through visits to nearby laboratories, and attendance at conferences and science fairs.

3.1 The Case of Barrios

Barrios is one of the two outstanding stories in a span of two years of the research program. His research project was published as "The use of convex lens as primary concentrator for multi-junction solar cells," in *Emergent Scientist*, an international journal. Certainly, there were co-authors such as the adviser, supervisors, and head of the collaborating laboratory.

Barrios' journey began when his adviser introduced the possibility of having a onemonth internship in a Japanese laboratory. He had to conduct his designed research (i.e., different aspects of solar cells) under several supervisors. Among the five of them, Barrios excelled in terms of skills and abilities acquired during the internship. His experience motivated him to investigate multi-junction solar cells.

The support of the science laboratory in providing materials, research articles, advice, and on-line consultation paved the way for the research to be materialized. It exposed him to recent findings and the problem of increasing the efficiency of solar cells. His inquiry experience culminated with his co-authorship of the research publication as expected of all scientists. He also presented his work in an international conference held in Tokyo, Japan.

4 Challenges and Scaffolds on Realities of Conducting Science Inquiry

Challenges are presented as barriers by Anderson (2002). Scaffolds are school-based initiatives to address the challenges when implementing a research program. Both are investigated here.

4.1 Teachers' Indifference Towards Teaching and/or Advising Research

School science teachers shy away from research teaching and/or advising for several reasons. The ultimate reason is their lack of formal training to become research teachers and advisers. Preciado Babb, Saar, Brandon, and Friesen (2015) observed that science teachers are simply reluctant to shift from their role in classroom. Teachers find the process of authentic inquiry messy due to its unstructured nature.

Unlike other subject area's research programs, science students have to work with an adviser with whom they share an interest. At our school, teachers have to adjust to students' research interests. Therefore, the Research Unit initiated team-teaching and mentoring. This scaffolding enables us to match the qualifications of research teachers with the research topic they are most likely qualified to teach. Likewise, students are also matched with their research advisers by encouraging them to apply for their research adviser whose knowledge, interest, and skills match theirs.

Ogawa (2002) did a study on how novice teachers gained expertise and the study revealed that a close daily-based deep, apprenticeship-typed or in some sense, family-type communication with peer science teachers in non-formal setting.

Preciado Babb et al. (2015) decided on teacher professional development project in order to engage high school students in authentic research. The researchers found that effective teacher training should resemble the authentic work of engineers and experts in the field. One example of teacher training that provides research experience is reported by Zhu et al. (2018). Teachers develop a capacity in engineering design and manufacturing research, which they taught their students.

If a research teacher fails to mentor effectively due to indifference, student researchers may develop a poor scientist identity (Robnett, Nelson, Zurbriggen, Crosby, & Chemers 2018). A teacher's indifference could take the form of a preconceived notion about the discipline, inexperience, a negative attitude toward the subject matter of interest to the students, plus other factors that influence how students identify with or pursue a topic of interest.

4.2 Students Are Neophytes in Research

Students simply lack the content and skills for conducting science research. Nikolova and Stefanova (2014) suggest that the major challenge of a neophyte is learning on how to work efficiently with new information. Their content knowledge is limited and their acquired expertise is too meager for them to comprehend research articles. As a result, they are required to undergo an internship in an authentic science laboratory. The experience acts as scaffolding.

Vicarious experience related to science research is acquired by passing a quick course or getting certified for a specific skill. For instance, students engaged in work units on aquatic-related research must show certification that they are licensed to swim or dive. Those in work units who have no experience on microbiological skills are already advised to take up Elective courses of their planned research projects. It is through an Elective course where students learn advance concepts and acquire laboratory skills. However, if content and skills are futile, students are sent to scientists in nearby research laboratories for consultation and mentoring. In Malaysia, Abdullah, Majid, Bais, Bahri, and Asillam (2018) also fostered research aptitude among high school students despite their being neophytes. The researchers rationalized that high school students have a competitive nature and introducing research is appropriate. Results of their study indicated that high school students are capable of conducting research with minimal guidance as long as step-by-step guidelines are provided. While this rationalizes the conduct of high school researchers, Kardash (2000) revealed that some research experiences and skills are enhanced better at certain school-age levels.

4.3 The Program Has Limited Research Infrastructure

Limitations to a program could be the availability of research mentors for the Unit, access to equipment, and a sufficient budget. The campus is located in the central Philippines where most mentors and equipment are scarce. Most scientists who could serve as mentors and offer equipment are concentrated in the capital in the northern part of the country. Students have to contend with whatever is available and with limited research infrastructure.

Scaffolds were initiated, such as partnership with nearby government agencies with qualified personnel who could serve as mentors. Parents were tapped to help out in the conduct of research. The Research Unit requires parents to participate at least in the research proposal defense and during the conduct of research tasks that pose hazards.

Since we attempt to define our science inquiry as the systematic approach of a scientist, we are faced with living up to the standards and expectations of scientists in the scientific community. Even when we get local scientists on board for the program, however, getting them involved posed several challenges (Andrews et al., 2005). Scientists consider their participation in a high school research program as being auxiliary to their more pressing responsibilities as scientists. There is usually a lack of time to do both. Scientists may be encouraged to engage more in whatever capacity if the school could address diverse issues such as classroom management, logistical or organizational problems, the outreach skills of scientists, and the value of outreach participation to augmenting a scientist's career path.

When Kirkup et al. (2015) did an inquiry with a national science agency, they added to this list of challenges: the duration of an investigation, explicit assistance in the use of supporting technology, and appropriate guidance.

4.4 Publication of Completed Research

At the school, research activity culminates with the preparation of a journal-ready manuscript that is reviewed by experts for journal publication. The school has already published a journal for high school research which is named as *Publiscience.* It is an open-access journal, accessible at http://publiscience.org, showcasing the work of high school students with the hope of sharing their outputs and inspiring other institutions to do the same. For instance, The School for Science and Math at Vanderbilt University has an innovative research-based program for high school students. The University is proud of the numerous publications in scientific journals that represent a culmination of their research programs (Eeds et al, 2014).

4.5 *Conducting Inquiry Is Competition-Driven and Principle-Bound*

It is a prevailing notion at our school that research is conducted to compete in research fairs and participate in research conferences. While fairs and conferences are ways to promote inquiry, student researchers are driven by its competitive nature. Research seems to be a product to be compared with other research projects.

The Research Unit addresses this challenge by formulating three guiding principles to live by. The first principle is to hold proper training as more important than the output. Proper training entails subscribing to appropriate standards when doing research. The student-driven approach in implementation and personal conduct assures that all students experience the research process from the problem formulation to the publication of a paper in a research journal. This research output must have gone through the appropriate processes, and student researchers must provide proof of their conduct.

The second guiding principle is that research must be for all students. Research is for everyone to experience and no one should be left behind. Even though they work as a pair or triad, student researchers must undergo the same research process and learn a minimum of competencies. This is achieved by letting students perform individually before collaborating their output as a work unit.

The third principle gives emphasis to the formation of character and life skills. When the first two principles fail to uphold the decision on research concerns, the Unit has to consider the implication on character and life skills. Students are informed of this research philosophy during their first meeting in research class. Parents are also informed during the parent–teacher conference. Research teachers and research advisers are held accountable to live by this three-principle research philosophy.

In a study conducted by Hu, Chang, and Lin (2003), they found that students favor the curriculum components of science in the following order: manipulative skills, scientific concepts, the application of science, social issues, problem-solving skills, and the history of science. An authentic research allows students to manipulate on their own and to see the scientific concepts in action and application. The research project addresses social issues and problem-solving skills. The history of science may only be seen in the review of related literature on how previous attempts were made to address the research problem.

As for participating in the science fair is concerned, a student may consider a study on the so-called “reverse science fair” that links secondary students with university researchers. Mernoff et al. (2017) found that the reverse science fair allowed high school students to increase: (a) their understanding of various applications of the methods found in scientific inquiry and (b) their interest in doing scientific research. The university researcher gained valuable experience by interacting with high school student researchers.

It is imperative that a research program be driven with learners as its core consideration. In fact, a student-oriented program led by them may reap benefits more than other drivers of inquiry. This was demonstrated by a youth-led participatory research that posed problems of concern to them (Ozer & Wright, 2012).

5 Conclusion

A contextualized approach is necessary for addressing and scaffolding inquiry-based teaching for secondary school students' efficacy at conducting scientific inquiry. As scientific inquiry's meaning is researcher- and problem-driven, it calls for an approach in these contexts. For instance, a contextualized approach may be researcher-centered to address the needs of the neophyte student researcher, because their challenge in doing research is their lack of experience. On the other hand, a problem-driven context could be appropriate standard protocols in conducting inquiry. As the campus is regional in scope and nature, with its unique delimiting factors in conducting inquiry, the problem-driven approach has proven to work with all its stakeholders. Teachers of inquiry must work with the students to achieve the goal of inquiry, while keeping in mind the school's vision, mission, and curricular framework. It is paramount that all stakeholders, such as parents, partner agencies, mentors, and school personnel, subscribe to this research philosophy. Lastly, learning inquiry should be the primary means to inculcate the holistic development of an individual as far as science inquiry skills and values are concerned, while the acquisition of content knowledge should be the secondary means.

The scaffolds, although not entirely devoid of limitations, have helped the campus-based implementation reap its success to immerse students in the major aspects of the research process. A few of the school's achievements are the conduct of school-based and community-based research congress, the participation in international science conferences, and the publication in a school-based journal, both in print and on-line. The program also boasts several research events such as research workshops, sharing of research skills, research pitching, and the desire to promote science inquiry among learners from other public elementary and secondary schools in the region.

A research area to investigate next would be the student's confidence in their research abilities and their understanding of what it means to be a scientist. A trustworthy evaluation tool should be implemented to assess the high school inquiry program with respect to students' gained abilities, knowledge, agency, and self-identities (Boyce, et al., 2019). Data-driven results may help policy makers come up with ways on how inquiry should be implemented at the practitioner level in meaningful and rewarding ways (da Palma Camargo et al., 2012). Fitzgerald et al. (2014) highest assessment criterion related to a student's research project is the student's capacity to conduct meaningful original research.

6 Implications for Science Education

The conduct of classroom scientific inquiry proves to be complex and transcendental. Making sense of the what, how, and why of inquiry causes it to be complex. It must be anchored in a research philosophy to which all stakeholders must subscribe. A well-grounded philosophy should be the guiding principle so that advisers, teachers, and student researchers can work well together. Just like any project-based learning, this scaffolding ensures that during their authentic inquiry, student researchers receive constant guidance and support (Hmelo-Silver, Duncan, and Chinn, 2007).

The classroom transcends beyond the physical structures used for research instruction. The instruction itself may take the form of research consultation, a dialog with scientists or experts, specialized trainings/lessons, and other research experiences.

Yet, the interaction of all stakeholders bounded by their own positionalities and beliefs creates complexity. Further complexity is generated by accommodating local views on what constitutes inquiry-based learning and what motivates it (Barab & Leuhmann, 2003).

Another issue concerns the research questions and problems formulated by students. Do students really raise meaningful questions to push the frontier of knowledge? Or do these research questions act as an educational exercise? Bielik and Yarden (2016) argue for the development of students' ability to ask research questions in an inquiry-oriented high school program which should be student-centered, dialogic, and interactive. It is also important to note that the entire experience should develop students' positive science dispositions. This requires that inquiry be technology-driven, builds a research team's cohesion, and disseminates their findings to the community. It must also entail researching with scientists, training under teachers, and acknowledging teachers' knowledge (Ebenezer, Kaya, & Kassab, 2018). McNally (2012) suggested that science inquiry must mobilize and collaborate toward a more engaged learner of science.

While the core of the research program is the learner, I strongly suggest that it must be well complemented with equal emphasis on research mentoring. In any authentic inquiry, learners may be the main investigator but the process should have research mentors who are well equipped to guide student researchers. The mentoring has, after all, a significant role in promoting a strong scientist identity as to the degree to which students perceive their science-related pursuits as integral to their self-identity (Robnett et al., 2018).

This chapter also stresses that a more authentic inquiry should provide an institutionalized interaction between scientists and students, not only during internships and professional science laboratories experiences. It cannot be underestimated how strongly the personal engagement of students with scientists influences students' development of a scientist self-identity.

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