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PRE-SERVICE BIOLOGY TEACHERS' EXPOSURE, UNDERSTANDING, ATTITUDE, SELF-EFFICACY, PREDISPOSITION, PROGRESSIVIST VIEWS, AND APPLICATION OF INQUIRY-BASED INSTRUCTION

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Abstract

BANSIONG, APLER J. University of the Philippines Open University, June 2019. Inquiry-Based Science Instruction and Biology Teacher Preparation: Exposure, Self-Efficacy, Predisposition, and Application.

Adviser: Maria Helen D. Catalan, Ph. D.

This piece of work described pre-service biology teachers (PSBTs) in terms of their exposure to inquiry-based science instruction (IBSI), and how they were able to apply IBSI practices during teaching practicum. Moreover, the study profiled the PSBTs according to their IBSI understanding, attitudes, self-efficacy, and predispositions, including their learner-centered views. Finally, the study determined the inter-relationships among the PSBTs' IBSI variables.

Sixty-six (66) PSBTs from three teacher-education institutions in Baguio City and Benguet participated in the study. Eight instruments were used to gather data -Science Teachers' Inquiry Practices Scale (STIPS), Pedagogy of Science Testing Test - Biology Items (POSTT-B), Attitude Scale for IBSI Use (ASIU), Inquiry-Based Science Instruction Self-efficacy Scale (IBSISES), Test for Inquiry Pedagogy in Science – Biology (TIPS-B), Modified Reformed Teaching Observation Protocol (mRTOP), Modified Inquiry Teaching Self-Assessment Instrument (mITSAI), and the Educational Philosophies Self-Assessment Instrument (EPSAI). The PSBTs lesson plans were also analyzed to support the result on the level of IBSI application during teaching internship. Follow-up interviews on both PSBTs and their cooperating teachers were also conducted to supplement the quantitative results gathered from the research instruments.

Descriptive statistics (mean and standard deviation) were used to summarize data, while inferential statistics (Analysis of Variance and Tukey HSD) were used to test for significance among means. Pearson correlation and step-wise multiple regression procedures were employed to describe the relationship among the PSBTs' IBSI variables.

Based on the findings, the study concludes that the PSBTs were sufficiently exposed to IBSI in all of its aspects – lesson planning and implementation, content knowledge, and classroom culture. They possessed a strong IBSI foundation which was built not only during their college science courses but also during their field study experiences and even during their pre-college science courses. While their IBSI knowledge and understanding were both insufficient, they nevertheless hold a very positive attitude toward the teaching approach, even regarding it as useful, interesting, and likable. The PSBTs highly adhere to the learner-centered philosophies, specifically constructivism and progressivism. They are highly self-efficacious toward IBSI specifically along classroom culture, but are moderately predisposed to select IBSI teaching practices among other pedagogical methods and techniques. Finally, the PSBTs were able to apply IBSI practices during teaching internship sufficiently. As to the relationship among the variables, the PSBTs' learner-centered views significantly correlated with their IBSI understanding and attitude, while attitude, self-efficacy, and learner-centered views significantly correlated with IBSI application during teaching internship. Moreover, the PSBTs' progressivist views significantly predicted their IBSI attitudes, and their IBSI exposure at field study was the only predictor of their IBSI self-efficacy. Meanwhile, IBSI understanding during lesson proper, and

IBSI self-efficacy along classroom culture emerged as the significant predictors of IBSI predisposition. Finally, IBSI exposure at field study, IBSI understanding during lesson proper, overall IBSI attitudes, progressivist views, and overall IBSI self-efficacy, significantly predicted IBSI application during teaching internship. Of these variables, overall, IBSI self-efficacy was the best predictor of IBSI application, followed by the PSBTs' progressivist views.

It is recommended that science professors should team up with science education professors in further strengthening the inquiry foundations of pre-service science students. Science education professors may emphasize the true nature of IBSI in their science teaching methods courses. Pre-service science teachers may be given more time to observe and experience inquiry practices in actual classes. Furthermore, some of the instruments used in this study could be polished so that they will effectively measure the constructs they are intended to measure. A more direct data-gathering procedure such as lesson plan analysis and/or actual teaching observation is likewise recommended for future researchers who want to duplicate this study. Moreover, syllabi and/or their laboratory manuals may also be analyzed as to how they emphasize on IBSI. Pre-service science teachers may also be exposed to the practices of lesson study, emphasizing on IBSI to instill its principles and practices better. For future research, the IBSI implementation among in-service teachers, how Filipino pre-service teachers implement IBSI practices during the first three years of teaching, how experiences or exposure with IBSI affect pre-service and in-service

science teachers' basic and integrated science process skills and scientific literacy, among others, may be explored.

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Chapter 1

INTRODUCTION

Background of the Study

The dilemma in the preparation of teachers has been on whether to emphasize on the content or the development of pedagogical skills (Lowenberg, 2000). Today, after more than a century, people are still asking the same old question. But decades of research on pedagogy contend that subject knowledge as a single ingredient for good teaching is not enough. Prospective teachers must also learn pedagogical techniques particular to the different disciplines to help them convey information and teach skills. Knowing subject matter and translating that knowledge to the lives of students is the key to learning (Wandberg & Rohwer, 2003).

The discussion on whether to emphasize content or pedagogy seems especially crucial in the teaching of science (Ward, 2012), since science educators and teachers are expected to foster in their learners the development of critical thinking and independent learning (Reaume, 2011). Besides, the scientific literacy goal of science education, according to the National Science Education Standards (NSES), is laid in the hands of science teachers [National Research Council (NRC), 2012]. To be scientifically literate, one must be able to read science materials with understanding, develop a full appreciation of where scientific information comes from, distinguish between science and technology, and explain how science and technology affect society (Trowbridge, Bybee, & Powell, 2000). Such abilities can be developed if K-12 science learners have experienced the process of inquiry and have used inquiry to learn science (NRC, 2012; Ward, 2016). With the study and

use of inquiry processes, K-12 learners become more scientifically literate – i.e., they can make sense of how the world works, and understand the scientific principles they encounter every day.

Inquiry-based science instruction (IBSI) is a set of teaching strategies that attempts to bring into the classroom the practices of the scientist. In IBSI, there is an emphasis on student questioning, investigation, and problem-solving. Like real scientists, students conduct their inquiries and investigations in the library, field sites, or laboratory, and discuss with their colleagues, in inquiry-based classrooms (DeBoer, 2004).

The goal of scientific literacy and the use of IBSI are the primary mandates in the Philippine national standards for science education (Department of Education, 2012). Curriculum experts in the field support these curriculum mandates for science education. Ogena (1998), for instance, emphasized that among other things, science education in the K-12 program must focus on hands-on science activities, emphasize on student research, and give attention to higher-order-thinking skills.

Informed with these current reforms in science education, teachers must adopt teaching and assessment strategies that develop scientific literacy among their learners. While in-service teachers of science may be trained using inquiry-based science instruction (IBSI), training must begin as early as during teacher-preparation. Pre-service science teachers (PSSTs) must be exposed to such pedagogical approaches. Researchers have found that modeling inquiry in pre-service classes helps students move away from didactic instruction to inquiry approaches (Schwartz & Guekwerere, cited in Martin, 2012). They must be trained in investigating

phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.

There are gaps in literature that this study addresses. Little has been written about the practice of inquiry-based instruction by science teachers in the Philippines, despite the recommendations in science reform standards. There is a dearth of research that documents the experiences of science teachers on the use of inquiry and other constructivist pedagogical approaches in the Philippines. Studies on these themes among pre-service science teachers are even scarcer. Hence, this study is proposed.

Moreover, the few international studies on pre-service science teaching and inquiry-based instruction documented the understanding and views about IBSI, or their self-efficacy to teach using the approach. Still, these constructs were not linked with the pre-service science teachers' actual application of IBSI in their actual student teaching experience. This gap is also addressed in this study.

Another gap that this study wishes to address is whether or not pre-service science teachers are exposed to IBSI practices during their pre-college, college, and the teacher-observation phase of their student teaching experience. Also, this study sheds light on the PSTs' predisposition to teach using IBSI and whether these predispositions translate into actual application during practice teaching. This important relationship has yet to be explored in literature. Finally, this study wishes to explore the moderating effect of the PSSTs' educational philosophies on their self-efficacy and predisposition to teach using IBSI, and their actual application of this teaching approach in their teaching internship experience.

Statement of the Problem

This study was conducted to determine the factors that influence the pre-service biology teachers' (PSBTs) IBSI understanding, attitudes, self-efficacy, extent of application of IBSI during their teaching internship experience, and their level of IBSI predisposition. Specifically, this study was undertaken to answer the following questions:

1. How do the following variables, taken singly, influence the PSBTs' IBSI self-efficacy?
   a) IBSI exposure
   b) IBSI understanding
   c) IBSI attitudes
   d) learner-centered views
2. How do the following variables, taken singly, influence the PSBTs' extent of application of IBSI during their teaching internship experience?
   a) IBSI exposure
   b) IBSI understanding
   c) IBSI attitudes
   d) learner-centered views
   e) IBSI self-efficacy
   f) IBSI predisposition
3. How do the following variables, taken singly, influence the PSBTs' level of IBSI predisposition?
   a) IBSI exposure
   b) IBSI understanding
   c) IBSI attitudes

d) learner-centered views

e) IBSI self-efficacy

4. How does the PSBTs' IBSI exposure influence their IBSI understanding?
5. How do the following variables, taken singly, influence the PSBTs' IBSI attitudes?

   a) IBSI exposure

   b) IBSI understanding

   c) learner-centered views

6. How are the following variables correlated?

   a) IBSI exposure

   b) IBSI understanding

   c) IBSI attitudes

   d) learner-centered views

   f) IBSI self-efficacy

   g) IBSI predisposition

   h) extent of IBSI application during teaching internship

Significance of the Study

Inquiry-based learning has been a national goal for most countries for decades. However, little is known about teachers' (pre-service and in-service teachers alike) views about the goals, purpose, or educational significance of IBSI. Moreover, more research is needed as to how pre-service teachers are exposed to it, their understanding and attitudes toward its use, their self-efficacy and predisposition to teach using the strategy, and their application of its principles during praxis. All of these endeavors are crucial since these pre-service science teachers are the ones who will lead the future facilitation of scientific literacy. Few studies dealt with some

of the above needs, but they focus on one or two concerns. One can hardly find studies on IBSI and Philippine pre-service science education as these studies have been conducted mostly in foreign settings.

The prospective science teachers' views about teaching and learning shape their future instructional approaches. Thus, as Crawford (2007) remarked - "It is a vital undertaking for science education professors to explore the PST views and make these views explicit in the context of teaching and learning."

As one of the first studies that explore IBSI and pre-service science teachers in the Philippines, the study contributes knowledge on how Teacher Education Institutions (TEIs) are performing their roles in instilling the principles of IBSI to their science education students. The result of the study could impact policies and decisions concerning the preparation of future science teachers. Some specific policies may include the strengthening or focusing on IBSI during science teaching methods courses, or the assignment of science major courses to instructors with strong foundations on reformed science teaching pedagogies. It might likewise strengthen the PSBTs' understanding of IBSI if lecture and laboratory classes in their science courses are integrated and not taken as separate courses. The practice in the case institution is that lecture and laboratory classes are taken separately, and sometimes taught by different teachers. Moreover, efforts must be made to reformat traditional laboratory exercises or experiments into inquiry-based activities. Other specific policy changes for science teacher preparation might include mandating all science education majors to use the 5E and related lesson plan models during teaching internship, using adherence to constructivist philosophies and inquiry-based teaching as an additional criterion in selecting future science teachers, emphasizing and strengthening IBSI during science methods courses,

providing in-service training to cooperating teachers and in-service teachers, strict monitoring of IBSI use in cooperating schools, among others.

It is likewise the intention of the study to develop a model that will explain the use of inquiry-based instruction by pre-service biology teachers during their teaching internship. Such a model may extend to the use of such a teaching strategy among in-service teachers in Biology. Another output of the study was a curriculum model intended for the use of pre-service science teachers in their methods of teaching courses. Specifically, a scope and sequence and a syllabus for a course on inquiry-based science instruction were included in the study.

Scope and Delimitation of the Study

This study involved pre-service biology teachers who are in their off-campus practice teaching stage in three teacher training institutions in Baguio City and Benguet, Philippines.

While reform documents also mandate inquiry instruction as a strategy among science and mathematics teachers, the pre-service mathematics and physical science teachers were not covered in the study. Moreover, while it may be beneficial to observe actual classes to see how the pre-service science teachers implemented inquiry instruction, it would be impractical as the use of such strategy is dependent on the subject matter and the teacher's objectives for the day. With the number of pre-service science teachers and the distance from the college to their cooperating schools, it would be challenging to observe every lesson they would deliver. To address this issue, the PSBTs' responses in the self-assessment questionnaires were validated by analyzing how they delivered the various instructional events in their lesson plans. Another limitation of the study is that it just involved three institutions in Baguio and Benguet. It would have been more desirable to look at

how other institutions in different parts of the country, and those with different set-up (such as the use of the self-contained scheme) view and apply inquiry instruction in their teaching internship experience.

Another limitation of the study is the use of arbitrary data that were mostly based on the PSBTs and their cooperating teachers' and students' potentially subjective assessments. Hence, the primary assumption of the study is that the above participants were honest in their assessments. This limitation was addressed by collecting qualitative data from interviews, lesson plans, and weekly journals. The findings of this study were thus interpreted in consideration of these constraints.

Chapter 2

REVIEW OF LITERATURE AND CONCEPTUAL FRAMEWORK

This chapter presents relevant information from research literature and studies that provide the relevant background information needed to understand the context of this paper. At the end of this review, the need for this study is justified to address the gaps in knowledge. The conceptual framework of the study, the hypotheses, and the definition of terms are also contained in this chapter.

Two Contrasting Teaching Models in Science

The various methods and strategies used in science teaching can be classified into two broad categories: (1) the behaviorist learning model, and (2) the constructivist-learning model (Roster, 2006).

The behaviorist model defines learning as observable changes in behavior (Llewellyn, 2005). A behaviorist teacher breaks the curriculum into smaller pieces of information, then evaluates how the students demonstrate their understanding of the new knowledge. The teacher sequences learning events from simple to more complex, which, in effect, is sending the message that learning can be predicted and controlled. The students' minds are seen as blank slates or empty vessels, ready to be filled by the teacher. The learner is treated as a passive participant. Rewards are given to the learners when their level of knowledge becomes similar to that of the teacher, or any other authority (Leonard, 2000). The behaviorist teaching model is teacher-centered, traditional, and predominantly lecture-based. Such a learning model has dominated educational institutions for the past century (Llewellyn, 2005; Roster, 2006).

In stark contrast to the behaviorist learning model is the constructivist learning model. Advocates of constructivism assert that the teacher cannot provide knowledge. Instead, knowledge is something directly experienced, acted upon, tested, or revised by the learner (Papert & Harel, as cited in Wandberg & Rohwer, 2003). Constructivism in the classroom implies that the learners are responsible for their learning, and the teacher is responsible for creating an appropriate learning environment (McNergney & Herbert, 2001; Wandberg & Rohwer, 2003).

A constructivist classroom is described by Bredekam and Copple (as cited in Wandberg & Rohwer, 2003) in the following words:

> "In the constructivist classroom, the learners are presented with opportunities to build on prior knowledge and understanding to construct new knowledge and understanding from authentic experience. Also, the students are allowed to confront problems full of meaning because of their real-life context. To solve these authentic problems, students are encouraged to explore possibilities, invent alternative solutions, collaborate with other students, try out ideas and hypotheses, revise their thinking, and finally, present the best solution they can derive."

Constructivist approaches permeated much of educational practice in the 1970s, but it became particularly popular in science education (Minner, Levey & Century, 2010). Constructivism occupied the centerpiece in the current reform efforts in science education, and this has resulted in the shift in the focus of teaching and learning from how students learn science to how teachers learn to teach science in teacher education programs (Taskin-Can, 2011).

The principles of constructivism as applied to science and mathematics teaching are outlined by Ishii (2003) as follows: (1) learning must start with the issues around which students are actively trying to construct meaning; (2) learning process focuses on primary concepts, not isolated facts; and (3) the purpose of

learning is for an individual to construct his or her meaning, not just memorize the correct answers and regurgitate someone else's meaning.

Constructivism comes in two forms – cognitive constructivism and social constructivism. The former, which was developed by Jean Piaget, believed that children learn through personal interactions with physical events and objects in their daily lives. When applied to teaching and learning, cognitive constructivists recommend the provision of opportunities and practical activities that challenge learners' prior conceptions and encourage them to recognize their personal beliefs and theories (Piaget, as cited in Holloway, 2015).

Social constructivism, on the other hand, emphasizes the importance of culture in the understanding of what is occurring in society and then constructing knowledge based on this understanding (Kim, 2001). According to Vygotsky (as cited in Holloway, 2015), who is the originator of the learning theory, learning is neither a purely internal process nor a passive shaping of behavior. It is a social construct, mediated by language via social discourse. In Vygotsky's words, "social interaction should be between an expert and the student and that the teacher is present to help students construct answers for themselves." The teacher models the disposition on how to view objects and events in new and imaginative ways, but he/she should neither dispense knowledge directly nor act as a mere observer (Prawat, 1996). In a nutshell, social constructivism tenets that people create meaning through their interactions with each other and with the objects in their environment (Prawat, 1996).

There are two main assumptions in the social constructivist theory. These are (a) knowledge is constructed by people who are active participants in the process,

and (b) social interactions within an individual or between individuals play an important role in constructing knowledge (Ferguson, 2007).

The teachers' use of either behaviorist or constructivist teaching models is largely dependent on their beliefs about teaching and learning. These held beliefs about the purpose of education, what should be taught and how it should be taught, the role of the teacher and the learners, all constitute a teacher's educational philosophy (Arends, Winitzky, & Tannenbaum, 2001).

Educational philosophies can be grouped into two broad categories – teacher-centered or learner-centered. The teacher-centered educational philosophies include perennialism, essentialism, and behaviorism. On the opposite side of the spectrum are the predominantly learner-centered philosophies of progressivism, social reconstructionism, and constructivism (Sadker & Sadker, 2003).

This study determines whether the respondents' educational philosophies moderate the influence of their IBSI background, understanding, and attitudes on their self-efficacy and predisposition to teach and apply the methods of inquiry in their teaching.

Constructivism and Inquiry-Based Instruction

Constructivism and inquiry-based learning are similar in that both stress that learning is a social process and learning occurs when people are engaged in social activities (Bybee & Fuchs, 2006; Kim, 2001; Prawat, 1996). Llewellyn (2002) even posits that the most popular way to teach in a constructivist manner is through a process called inquiry teaching. Inquiry-oriented teaching is often contrasted with more traditional behaviorism-inspired expository methods, and it reflects the constructivist model of learning (Haury, 1993). Constructivism-based materials are commonly classified as inquiry-based and include hands-on minds-on activities as

means to motivate and engage students while making science concepts concrete (Cakir, 2008; Minner, Levey, & century, 2010).

Both cognitive and social constructivist theories are useful in developing lessons in an inquiry-based classroom. An inquiry-based classroom is one that possesses the following characteristics: (1) the teacher should consider the knowledge and experiences students bring to the class; (2) learning is presented as a process of active discovery, not lecture; (3) teachers assist with assimilation of new and old knowledge; (4) learning is sufficiently flexible to permit development along lines of student inquiry; (5). teachers allow students to interpret information in different ways; (6) teachers should create situations where the students feel safe questioning and reflecting on their processes; (7) teacher should present authentic tasks to contextualize learning through real-world, case-based learning environments; (8) teacher should support collaboration in constructing knowledge, not competition; (9) teacher should provide scaffolding at the right time, and the right levels; and lastly, (10) teachers should provide opportunities for all students to learn from each other (Jordan, Carlile, & Stack, 2008).

Features of Inquiry-Based Instruction

In the recent past, although standards have already been pushing for the use of inquiry-based approaches as a form of science education reform efforts, there seems to be a lack of a universally-accepted definition of inquiry-based teaching and learning. As a result, science educators interpret scientific inquiry in many different ways according to how they use the term in their teaching. These various interpretations prompted the National Science Education Standards (NSES, NRC, 1996) to release a standard definition of inquiry. In the document, the NSES defines inquiry as "a set of interrelated processes by which scientists and students pose

questions about the natural world and investigate phenomena. In doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories" (p.214).

There are various terms in literature that are used interchangeably with inquiry-based instruction – inquiry learning, inquiry-based learning, or inquiry-based teaching (Sureci, Tarihi, & Tarihi, 2016). These terms were treated the same in this study, and each term can substitute for another without changing its meaning. Generally, these pedagogical approaches involve inquiry skills from asking questions about the topic to be learned, then searching for possible answers, and constructing new knowledge during the research, to discussing the findings and experiences, and reflecting on the newly acquired knowledge (Taskoyan, as cited in Sureci, et al., 2016).

As the Philippines sees the attainment of scientific literacy as its ultimate goal for science education, the national standard for K-12 Science Education recommends the use of inquiry-based instruction approaches at all levels of education (DepEd K-12 primer, 2012). With this mandate, learners are expected to be engaged in inquiry activities and to learn science through inquiry. Engaging in inquiry and learning science through inquiry could imply similar ideas. The term inquiry instruction is used to refer to how teachers structure learning activities to target the goals of having students do inquiry to learn science concepts (Ward, 2016).

Inquiry-based instruction requires or subsequently develops problem-solving skills, and inquiry and documentation skills, among others (Friesen & Scott, 2013). Stripling (as cited in Sureci et al., 2016) had visualized inquiry-based learning as a

model which covers the following six steps: Curiosity, inquiry, construction, description, reflection, and association.

There is apparent confusion in literature as to the relationship between inquiry-based learning and other heuristic teaching strategies such as project-based learning, problem-based learning, and design-based learning. Such confusion may have resulted from the absence of a clear-cut definition of inquiry-learning in the first place. For instance, Stephenson (2014) regarded project-based learning, problem-based learning, and design-based learning as specific strategies used in inquiry-based instruction. The notion of problem-based learning as a method of teaching through inquiry is supported by Allen and Duch (as cited in Roster, 2006). Other authors argued that inquiry-based learning, together with project-based learning, and discovery learning, are under the bigger umbrella of problem-based learning (Kauchak & Eggen, 2012). Still, others would see inquiry-based learning as pedagogically distinct from problem-based learning (Oguz-Unver & Arabacioglu, 2014).

To guide teachers in their attempt to incorporate inquiry instruction into their classroom, the National Science Education Standards (NRC, 2000) provided a list of five essential features of inquiry. These steps are linked to particular cognitive behaviors that students should engage in during inquiry learning events. These five essential features are (1) students should engage in scientifically-oriented questions, (2) students give priority to evidence, (3) they construct explanations using evidence, (4) they connect these explanations to scientific knowledge, and (5) they communicate and justify their explanations. In reality, however, there are multiple variations of what this might consist of in any teaching and learning event. So, the NRC (2000), released a matrix in the form of a continuum that delineates inquiry

events from structured, or highly guided inquiry to open inquiry. This continuum moves from inquiry events of more teacher guidance (structured or guided inquiry) to less teacher guidance (open inquiry) (Bell, Smetana, & Binns, 2005; NRC, 2000; Ward, 2016).

In guided discovery, the teacher selects the topic, introduces the unit and the lessons, and provides a structure for the investigation. The teacher develops the initial activity, asks questions, and helps the students in their endeavors, not his or her endeavors. The teacher probes by asking more questions – some leading and others intended to find out what the learners are thinking. In a nutshell, the teacher is a guide, a resource person, and a co-inquirer (Martin, 2012).

In open inquiry, sometimes called free discovery, the learners decide on what is essential for them to learn. These learners set up their unique learning activities to explore the topics they have chosen; they devise and explore their inquiry situations. They look at reference books, electrical and digital resources, magazines, peers, the Internet, and other sources of information to see what has been learned before. The teacher acts as a resource and co-inquirer, and the students are deeply involved cognitively (Martin, 2012; Trowbridge et al., 2000).

Obviously, not all teaching and learning events involve the five features of inquiry. As such, inquiry events may be described as full or partial inquiries depending on the number of essential features present (NRC, 2000). The level of inquiry is dependent in part on the context (e.g., students, topic, previous experiences with inquiry, time, and resources available) and in part by the goals of the lesson and the skills of a teacher (Ward, 2016). While the students are not expected to participate in all the inquiry practices during any given learning event,

the components of these practices should pervade all inquiry-based teaching and learning events (Osborne, 2014; Ward, 2016).

It should not be misconstrued from the inquiry continuum that one level is better than the other, say open inquiry is better than guided inquiry. As earlier described, the level of inquiry used is dependent on teaching and learning goals as well as on other factors (e.g., grade level, subject matter, student and teacher experiences, intended learning outcomes, resource availability). To illustrate this point, if the goal of instruction is to help students develop their abilities to do inquiry, then varying levels of openness should be provided. If the goal is for the learners to master conceptual knowledge, then more teacher-guided inquiries should be used. The goal of the NSES is for teachers to provide students multiple opportunities to engage in all inquiry practices at various times in their learning careers (NRC, 2000).

The goal of education is not to have students do science as scientists do. The advocacy of the NSES is that students participate in science-like processes, or do inquiry processes. The inquiry activities students engage in are asking questions, developing and conducting investigations, analyzing data, formulating explanations from evidence, and communicating findings (Ward, 2016). As emphasized in some reform documents (NRC, 1996; 2000), in doing inquiry, students use critical thinking during multiple and diverse inquiry contexts (e.g., laboratory, field studies, computer, or library research). To be truly engaged in an inquiry-based lesson, students should go beyond finding answers to their questions. They must also use scientific knowledge to evaluate their results and critique the findings of others (NRC, 2012; 2000). The use of IBSI is then based on the premise that learning is an active process, and it involves both hands-on as well as minds-on approach to teaching

(NRC, 2000). Such an approach in science teaching is unfortunately far removed from what is happening in most science classrooms today.

Finally, it should be noted that not all science subject matter could or even should be taught by inquiry method (NRC, 2000). To insist on the inquiry approach as a single pedagogical mode is also impractical, impossible, and unwarranted (Osborne, 2014; Ward, 2016). The expository methodology still has a place in science education. This direct instructional approach could be valuable when a teacher needs to present new information to the whole class as a background for upcoming lessons. Direct instruction is likewise useful when a teacher gives useful directions involving safety measures, or when an activity needs to be demonstrated by the teacher before the learners work on their own (Martin, 2012).

Inquiry-Based Instruction and the Philippine Science Education Framework

In the Philippines, as in many countries, the current direction of curriculum development is toward scientific literacy, where the science education needs of all students are differentiated from those who have an interest in scientific careers (SEI-DOST & UP NISMED, 2011). According to the Science Framework for Philippine Basic Education, the vision of science education in the country is "the development of scientifically, technologically, and environmentally literate and productive members of society. These skills will be acquired through a curriculum that focuses on knowledge relevant to the real world and encompasses methods of inquiry." (p. 3). Thus, the Philippine science education framework advocates the use of inquiry-based instruction (IBI) as a teaching approach in science for the Filipino learners to develop scientific and technological literacy.

Inquiry-Based Instruction and Professional Development: The Role of Lesson Studies

To many scholars, central to any educational reform, such as the enactment of inquiry-based instruction in science lessons, is through collaborative working toward a common goal (Darling-Hammond & McLaughlin, 2011; Pugach & Johnson, 2002). More than improving their professional well-being and their students' learning (Louis, 2006), collaboration provides an opportunity for teachers to improve with the help of the thought processes of their peers (Bower & Richards, 2006). A productive professional development endeavor is something that provides teachers with opportunities and appropriate support structures that encourage them to work critically on the continuous improvement of their pedagogical knowledge (Darling-Hammond & McLaughlin, 2011).

The principles of lesson study capture the essence of collaboration, emphasizing on the importance of social interaction through negotiation, discourse, reflection, and explanation in the construction of knowledge. Lesson study coincides with the idea of situated learning where their classrooms are the best venue for teachers to learn and improve their teaching practice (Gutierez, 2014; UP NISMED, 2015).

A lesson study involves a group of three to five teachers, usually within the same grade level, who meet regularly and collaboratively to investigate a "research lesson" that is designed to impact student achievement (Cheung & Wong, 2014). Initially, the lesson study group members work together to identify a curricular goal within a content area, and set goals for their students' improvement (Puchner & Taylor, 2006; Saito & Atencio, 2013).

Lesson study, which originated from Japan, follows a cyclical step which involves: 1) collaborative goal setting and planning the study lesson (Fernandez & Yoshida, 2004; Gutierez, 2015) or research lesson (Lewis, 2002); 2) implementing and observing the research lesson; 3) debriefing and reflecting on the observed lesson; 4) revising the research lesson (optional or whenever necessary); 5) teaching the revised research lesson (optional or whenever necessary); and 6) sharing of thoughts about the outcomes of the research lesson or post-lesson reflection and discussion (Gutierez, 2014; 2015).

Through observation, post-lesson reflection, and discussion, teachers are provided the opportunities to discuss the challenges they encountered during lesson implementation. More importantly, the lesson study group could suggest possible improvements for the teachers to address, and for him or her to eventually develop new teaching techniques (Saito & Atencio, 2013). A synthesis of the teachers' professional learning, which incorporates the revised research lesson to be pondered upon in subsequent research lesson implementations, will serve as the final activity (Chokshi, 2002; Takahashi & Yoshida, 2004).

With the qualities mentioned earlier and the importance of professional development, the lesson study framework is seen as a potential professional development model in the Philippine educational setting, especially in the understanding of inquiry-based instruction. The lesson study procedure can help deepen the content knowledge of teachers, which, according to the National Science Education Standards (NSES), must be the essence of most professional development activities (NRC, 1996).

The University of the Philippines National Institute for Science and Mathematics Education Development (UP NISMED) promotes lesson study as a

professional development model for teachers, and its experiences and research findings were published in two volumes on lesson study. One study investigated the practice of inquiry-based teaching and learning among elementary science teachers from a public school in Metro Manila (Gutierez, 2015). Using a qualitative case study design, the researcher gathered the teachers' insights, experiences, and challenges in implementing inquiry-based teaching. Results of the interviews and post-lesson reflections and discussions revealed three barriers to inquiry teaching: 1) the lack of support, training and available inquiry-based materials; 2) the overemphasis on assessing content learning rather than learning through inquiry; and 3) the misconception, difficulty, and time - consuming nature of inquiry-based teaching.

Inquiry Teaching Methods

Roster (2006) identified four methods that are often used in inquiry teaching. While all four methods tend to overlap in some respects, there are some distinctions among them. These four methods are experimental projects, problem-based learning, learning-cycle, and the scientific inquiry method.

One inquiry teaching method is to involve students in long-term experimental projects. A long-term experimental project is an authentic method by which students understand how scientists think and work, and for them to acquire the skills and knowledge they need to think and act themselves scientifically. One example of the application of such a method is when an instructor replaced the ecology and environmental science unit with a five-week-long class project (Petersen, 2000). Here, students were asked to conduct an experiment and analyze their results statistically. Students in these classes were required to perform all the tasks faced by contemporary scientists, including such trivial matters as balancing a fictitious budget, and applying for collection permits. The subjects consisted of honors

students and regular students. Both groups showed development and improvement in interdisciplinary skills related to science and a greater understanding of scientific papers and data interpretation. Interestingly, the honors students gained more understanding and appreciation for science than did regular students.

A local example of experimental projects as inquiry methods is the requirement of an investigatory research project among high school students and elementary pupils in the Philippines. Here, students are asked to formulate a research question based on a local problem, and use the inquiry processes to come up with solutions to these problems. Results are presented both orally and in poster form in science fairs.

Problem-based learning (PBL) is a form of guided inquiry that centers on the solution of problems (Martin, 2012). Here, the students are presented with a problem, a query, or a puzzle that they will solve (Allen & Duch, 1998, cited in Roster, 2006). The problems to be presented must be both complex and authentic so that students are motivated to search for answers or solutions.

The main principle of PBL is based on maximizing learning through investigation, explanation, and resolution by starting from real and meaningful problems. Therefore, PBL is the art of problem-solving (Oguz-Unver & Arabacioglu, 2014).

The problems used in PBL must be ill-structured and allow for free inquiry (Oguz-Unver & Arabacioglu, 2014). The teacher continually probes learners' thinking and learning by asking the questions, "Why?" "What do you mean?" "How do you know that's true?" (Oguz-Unver & Arabacioglu, 2014). The instructor's role is that of a facilitator and a coach rather than a leader. Moreover, the problem-solving element of PBL requires learners to look at multiple perspectives and domains. According to

Savery (as cited in Oguz-Unver & Arabacioglu, 2014), learners should be able to access, study, and integrate information from all the disciplines. These multiple perspectives lead learners to a more thorough understanding of the issues and the development of a more robust solution through PBL.

A familiar teaching approach to inquiry teaching is the learning cycle approach. The cycle consists of three to five phases. In the three-phase model, the first phase is the Exploration Phase, where students generally interact with each other to solve a problem or complete a task (Allard & Barman, as cited in Roster, 2006). The problem is open-ended to allow students to be creative yet directed in their problem-solving. However, the teacher can narrow the field of possibilities. This phase also allows students to share ideas about something familiar to them, and try to relate the problem to different concepts (Beisenherz, Dantonio, & Richardson, 2001). For example, to begin a unit on plant organs, students may investigate the differences between monocot and dicot roots by observing different live specimens. They then draw and discuss observed differences.

During the second phase of the cycle, Concept Introduction, the students are introduced to the main concepts of the lesson and any pertinent vocabulary. Here, students report findings accumulated during the exploration phase. The instructor then uses the information provided by the students as a springboard to discussions (e.g., the difference between monocot and dicot roots).

The final phase of the learning cycle is Concept Application. In this phase, students study additional examples of the main concepts. Such additional studies may lead to a new task where students are asked to apply learned concepts to new situations such as identifying unknown root specimens (Allard & Barman, 1994).

The five-step version of the learning cycle is also known as the 5-E model. In the 5-E model, the first phase is engagement. Here the teacher sets the stage for the lesson, explains the objectives, and focuses the students' attention. During the Engagement phase, the instructor can also assess prior knowledge and have students share their experiences. Such an instructional sequence is reflective of the constructivist view (Llewellyn, 2002).

The second phase is the Exploration phase, where students raise questions, develop hypotheses to test, gather evidence and data, and share with other groups.

The third phase of the 5E model is the Explanation phase. The teacher guides the students through data-processing techniques and how their data relate to scientific concepts. The teacher may introduce more details and vocabulary to provide a common language for discussion of their results (Llewellyn, 2002).

The next phase in the model is the Elaboration or Extension phase. The teacher reinforces concepts by applying gathered evidence and data to new and real-world situations. Here, new knowledge is added to the learners' conceptual framework.

The final phase of the 5-E method is the Evaluation phase. During this phase, both the teacher and the students summarize the relationships among the variables in the exploration and explanation phases. The teacher may also pose questions to the students to get them to make judgments and analyze their work (Llewellyn, 2002). The teacher can likewise make comparisons between knowledge shared in the Engagement stage and new knowledge acquired throughout the lesson. This evaluation then may lead to another Engagement.

The fourth inquiry teaching method is scientific inquiry. In contrast with the three other teaching methods described in the preceding section, scientific inquiry is

not easily described apart from the context of particular investigations. There simply is no fixed set of steps that scientists always follow, no one path that leads them unerringly to scientific knowledge. There are, however, certain features of science that give it a distinctive character as a mode of inquiry. Although those features are especially characteristic of the work of professional scientists, everyone can exercise them in thinking scientifically about many matters of interest in everyday life (AAAS, as cited in Roster, 2006)

Scientific inquiry learning can also be viewed as a cycle (Llewellyn, 2002) and is divided into phases. These phases are 1) Inquisition where the lesson starts with a question to be investigated; 2) Acquisition where students brainstorm possible solutions to the problem; 3) Supposition where students select which solution to test. 4) Implementation: Students design and carry out an experiment. 5) Summation: Upon collecting evidence, students draw conclusions. 6) Exhibition: Students communicate their findings to other students. During this exhibition phase, students may discover more questions to be answered and thus start back at the inquisition phase.

Some subtle differences separate the learning cycle and the scientific inquiry method. One difference is that during the learning cycle, the second step is devoted to learning the terminology and the main concepts. This stage is absent in the scientific inquiry method and could be done before, during, or after the inquiry process. Also, the scientific inquiry method more closely models the scientific method and that which scientists do every day (Windschitl & Buttemer, 2000), than does the learning cycle. Finally, the scientific inquiry method is more flexible than the learning cycle and is more representative of how scientists engage in problem-solving.

The subtle differences among the four inquiry teaching models can be summarized as follows: The experimental project method involves more long-term projects that may have research teams and even fictitious budgets. Problem-based learning generally employs case studies. The learning cycle is a structured method that may give inexperienced students a better idea of the process of science. Finally, the scientific inquiry method is somewhere in between these methods. It allows for the flexibility of short and long-term projects, it may follow defined steps or allow students the freedom to jump around within the process, and it may start with a case study (Roster, 2006).

Benefits of Inquiry-Based Instruction

The rationale for the focus on inquiry learning is multifaceted and is embedded in research about learning (Bransford, Brown & Cocking, as cited in Ward, 2016), and more specifically, how students learn science in the classroom (Donavon & Bradsford, 2005). An inquiry-oriented classroom is one that has a constructivist learning atmosphere that encourages students to raise questions and be able to propose feasible ways to solve problems (Lee & Shea, 2016; NRC, 1996). When students acquire ideas through inquiry-based instruction, whether through short-term or long-term investigations, they learn better than through traditional didactic or direct instruction approaches (Blanchard, Southerland, Osborne, Sampson, Annetta & Granger, 2010; Lee & Shea, 2016). Also, with IBSI, students can construct their knowledge based on their authentic experience and questions to be investigated. This knowledge construction is far more meaningful learning than merely verifying the correct answer from "cookbook" laboratories. Moreover, inquiry-based instruction provides students with repeated exposure to science concepts. It

allows them to scaffold their understanding into what becomes their long-term memory (Marshall, as cited in Lee & Shea, 2016).

Another benefit one can derive from inquiry-based instruction is its ability to promote more in-depth and more meaningful learning (NRC, 2000; Tatar, 2012). When learners interact with teachers, other learners, and learning materials, they develop deeper meaning and understanding of new knowledge, as well as higher-level thinking skills (Anderson, 2007).

Inquiry-based teaching approaches do not only develop the learners' cognitive faculties. This approach also affects learners' affective skills (Gibson & Chase, 2002; Yager & Akcay, 2010). When exposed to IBSI approaches, learners claim that they were more involved in the learning process, and they find the approach more favorable to their learning (Abd-El-Khalic, BouJaoude, Duschl, Lederman, Namlok-Naaman, Hofstein, Niaz, Treagust, & Tuan, 2004). They took responsibility for their learning (Plevyak, 2007). In other studies, the benefits of inquiry-based instruction that have been observed were enhanced students' performances in laboratory skills and interpreting data (Mattheis & Nakayama, 1988). An inquiry-based classroom promotes critical thinking skills. It empowers students to become independent and lifelong learners (Llewellyn, 2005). According to Reagan, Brubacker, and Case (2000, p. 2), "inquiry-based classrooms promote critical thinking skills and habits of mind."

Another study examined the effects of IBSI on the academic achievement, attitudes, and engagement of fifth-grade science students (Maxwell, Lambeth & Cox, 2015). Using quasi-experimental procedures, the team of researchers gave the experimental group IBSI instruction while the control group received traditional instruction. Pretests and posttests were used to measure academic achievements

during the six-week study. The Science Attitudes Survey was administered to students to assess overall student attitudes toward science. Student engagement was measured three days a week with a student engagement checklist. Though statistically insignificant, the results saw students in the IBSI group scoring higher than students in the traditional group. Students who received IBSI instruction showed a slight statistically insignificant decrease in their positive attitudes toward science but higher engagement as compared to students who received traditional instruction.

Science Teachers' Beliefs about Teaching and Learning Science

The role that teachers' personal beliefs about teaching and learning and how these beliefs influence their instructional decision (Luft & Roehrig, 2007; Pajares; 1992), and the role that teacher education has impacted these beliefs (Crawford, 2007; Keys & Bryan, 2001; Luft & Roehrig, 2007) have been the focus of studies for several years. Several researchers asserted that the teachers' beliefs about teaching and learning science are likely predictors of their intentions to teach science through inquiry (Crawford, 2007; Luft & Roehrig, 2007; Tillitson & Young, 2013).

In a study by Crawford (2007), five intern teachers over one year were followed to explore their beliefs about teaching, understanding of inquiry, and how they attempted to carry it out in actual practice. With semi-structured interviews, inquiry-based unit plans, classroom observations, and journal entries documenting informal conversations as data-gathering procedures, it was suggested that the "prospective teacher's personal view of teaching science as inquiry, comprised of his or her knowledge of scientific inquiry and inquiry-based pedagogy and his or her beliefs of teaching and learning, is a strong predictor of a prospective teacher's actual practice of teaching science" (p. 636). In this study, the interns who espoused

informed views of inquiry were able to carry it out in practice. This study further suggested that prospective science teachers need to clearly articulate to themselves and to potential critics why an inquiry approach is a valuable pedagogy. They should be able to articulate personal learning philosophies supported with evidence that make connections between inquiry instruction and how students learn.

Teachers' belief about teaching and learning science is sometimes subsumed under the umbrella of orientations to teaching science (Cobern et al., 2014; Friedrichsen, Van Driel, & Abell, as cited in Ward, 2016). According to Friedrichsen and his colleagues, science-teaching orientations have three dimensions: "Beliefs about the goals or purposes of science teaching, beliefs about the nature of science, and beliefs about science teaching and learning" (p. 373, cited in Ward, 2016). In this study, teachers' beliefs about teaching and learning, the role of schools, teachers, and learners, were treated as the respondents' predominant educational philosophies.

Inquiry-Based Instruction and Science Teacher Preparation

The primary aim of science teacher education is to prepare pre-service teachers for teaching science through inquiry as supported by the constructivist theory (NRC, 1996; Tatar, 2012). Science teacher education is a crucial task as its purpose is to develop future teachers of science who will become the representatives of the science community in their future classrooms. These future science teachers are to model the process of scientific enterprise in their classrooms, and they form much of their image of science through the science courses that they take in college (p. 61).

It is then a must that professors in college science design courses that are heavily based on investigations. Here, future science teachers have direct contact with phenomena, and they are to gather and interpret data using appropriate technology. Likewise, they are involved in groups working on real, open-ended problems. Science courses must allow teachers to develop a deep understanding of accepted scientific ideas and how they were formulated. They must also address problems, issues, events, and topics that are important to science, the community, and teachers (NRC, 2012).

Inquiry instruction is a complex and dynamic activity (Crawford, as cited in Ward, 2016), and helping pre-service science teachers learn to plan for and utilize this engaging pedagogical approach is a daunting challenge that is not well understood. It is mandated in some reports that teacher preparation should include some of the same elements recommended for the K-12 instruction (NRC, 2012; 2000; 1996). Prospective science educators must then be prepared for K-12 science teaching by providing them opportunities to (a) do science inquiry, (b) learn about scientific inquiry, and (c) learn science through inquiry (Ward, 2016). In the National Science Education Standards (NRC, 1996), prospective and practicing science teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop an understanding (p.62).

However, the authors of the 1997 Salish I Research Project indicate that many pre-service teachers do not apply inquiry-based instruction in their courses after their undergraduate education (Brown & Melear, 2006; Tatar, 2012). The lack of inquiry-based science in schools could be attributed to the limited enactment of inquiry methods in science classrooms, both in high schools and undergraduate

schools (Roth, & McGinn, 1998). Pre-service science teachers took science courses that did not prepare them for authentic scientific inquiry. Similarly, Duschl and Osborne (2002) argued that the use or non-use of inquiry-based principles is affected by a teacher's experiences in the science classroom. Also, pre-service or in-service science teachers may believe in the value of hands-on experiences for children, but they may not know how to translate these into classroom content for the children. Such facts imply that pre-service science teachers must be allowed to learn the IBSI way, i.e., learn new (and rigorous) content by building on prior knowledge and engaging in social interactions. As stated by Crawford (as cited in Tatar, 2012), pre-service teachers should make explicit the connections between an inquiry process, their understanding of how people learn science, and their teaching practice.

Teachers' Conceptions and Views of Inquiry-Based Learning

Most of the envisioned reforms in science education are seen to be mostly incongruent with classroom practices (Lakin & Wallace, 2015; Osborne, 2014). Many science teachers are not familiar with the contemporary views of science education reforms, such as constructivist theories of learning, conceptual change theory, and the learning cycle. They also have limited knowledge of teaching and learning theories (Young, 2013). Even experienced teachers lack knowledge of reform documents related to inquiry-based teaching and learning (Kang, Orgill & Crippen, 2008; Young, 2013).

In his literature review, Llewelyn (2002) noted that teachers have many misconceptions and myths about inquiry-based science teaching (as cited in Lee & Shea, 2016). He found out that most teachers in the elementary claim that they are

using inquiry-based science as they are doing hands-on activities. Many teachers think they are doing inquiry instruction when, in fact, they do not (Capps & Crawford, 2013). Such an erroneous notion of inquiry enactment holds among Filipino elementary science teachers, who equate inquiry-based instruction with giving activities or laboratory experiences (Gutierez, 2015). These teachers mistakenly equate inquiry-based instruction and hands-on. It is clear then that not all hands-on activities are inquiry and vice versa. Haury (1993) clarified the seemingly superficial notion of inquiry by stating that physically doing the activity is not the most essential element of learning about science. To be classified as inquiry-based, an activity should involve students posing questions, gathering data, reasoning from evidence, and communicating explanations based on the collected data. While hands-on activities are essential, the students must also be engaged in minds-on activities (NRC, 1996). In addition, Llewelyn (2002) points out that the questions asked must be open-ended, leading students to design investigations to answer their questions. Clearly, in-service and pre-service teachers alike, have an insufficient understanding of scientific inquiry. Both groups are not confident about their understanding of inquiry (Tatar, 2012). Such insufficient understanding of inquiry can undermine their self-efficacy to teach science through inquiry.

Other myths that teachers hold on inquiry-based learning is that the strategy is useful in developing laboratory skills by using laboratory tools and following cookbook-style procedures and confirming predetermined outcomes or verifying the existence of a scientific principle (Osborne, 2014). These descriptions certainly do not fall under the definition of inquiry. More importantly, these naïve ideas about inquiry teaching and learning preclude the rich and robust nature of true inquiry teaching (Ward, 2016).

Many individuals view scientific inquiry as a sequence of steps that scientists follow when they conduct investigations. This myth is often perpetuated in science textbooks as the "Scientific Method" (McComas, 1998). The use of a single scientific method is a gross misrepresentation of both the nature of inquiry and the nature of science (McComas, 1998).

One popular myth about inquiry-based instruction is that it is equivalent only to minimally-guided instruction or discovery learning (Clark, Kirschner & Sweller, 2012). These ideas seem to raise the wrong message that neither structured nor open inquiry work for students. Such a notion negates the significant role the teacher plays in carefully designing and scaffolding the learning activities to ensure the attainment of the learning goals (Hmelo-Silver, Duncan, & Chinn, 2007; Llewelyn, 2002, Wilcox, Kruse, & Cloughs, 2015).

On the other hand, there is a persistent idealized notion that an open inquiry is the preferred form of inquiry that teachers should strive for in their classrooms. In a survey among 19 college professors, it was noted that these professors viewed inquiry as totally student-driven, with students asking questions, designing investigations, and collecting data. These ideas communicate the wrong notion that inquiry is "unstructured, time-consuming, and difficult to enact" and applicable only to higher-level students (Brown et al., 2006, p. 798). These ideas are inaccurate and problematic and need to be extinguished as they could discourage teachers from implementing inquiry practices in their classrooms.

Pre-service science teachers as well, hold certain myths about inquiry-based learning. However, research in this field is quite limited. In a study conducted by Lee and Shea (2016), most pre-service science teachers hold a simplistic view of inquiry-based learning. Most of them think that inquiry learning is asking students questions

rather than it being a formal set of pedagogical tools. Similarly, Magee and Flessner (2012) examined pre-service elementary teachers' concepts of inquiry-based teaching. Most of them believe that inquiry is "laissez-faire" and chaos. To the pre-service science teachers involved in a study, IBSI allows teachers to teach anything or in whatever way they prefer, and that it is unorganized pedagogy. All of these misconceptions are indicative of their inexperience with inquiry-based science instruction, both in their science content and teaching methods courses.

There is considerable evidence that the beliefs or views of pre-service teachers affect how they learn and how they approach teaching in the classroom (Richardson, 2003). Several factors influence these views or beliefs. These factors include teacher beliefs about students and student learning, the nature of science, epistemology, and the role of a teacher (Wallace & Kang, as cited in Tatar, 2012). A teacher who wants to implement inquiry-based science education must have rich and deeply developed understandings of science content, student learning, the nature of science, and ways to engage students in investigative practices (Keys & Bryan, 2011). He or she must adhere to and accept the more constructivist views of learning, rather than on the behaviorist perspectives. Science teacher preparation programs must continue to promote inquiry instruction and explicitly target helping pre-service teachers develop accurate conceptions and how to identify it from other teaching strategies (Binns & Popp, 2013; Ozel & Luft, 2013; Saad & BouJaoude, 2012).

Pre-service Science Teachers' Exposure with IBSI

Pre-service teachers bring varying experiences with inquiry-based science instruction when they come to their teaching preparation programs. These variations may come in the form of the degree of exposure, or the feelings and attitudes

evoked during the inquiry experience. These experiences on inquiry instruction can contribute to the identities they develop on the use of such teaching approaches (Melville, Fazio, Bartley & Jones, 2008). These experiences can potentially encourage or discourage the development of a teacher's confidence in the use of inquiry in the classroom (Flores & Day, 2006; Melville et al., 2008).

Several studies have reported on pre-service teachers' inexperience with inquiry-based instruction both in their basic education and teacher-preparation years (Anderson, 2007; Crawford, 2000; Friesen & Jardine, 2010; Windschitl, 2004). The majority of science students are not exposed to teaching that "encourages undergraduates to become actively involved in their learning (i.e., scientific learning)" (DeHaan, as cited in Melville, et al., 2008). These result in pre-service science teachers who have undergraduate degrees in science struggling with the purpose and pedagogy of an inquiry-based science curriculum.

The importance of pre-service teachers' inquiry experience and their capacity to use inquiry in the classroom is reflected in the work of Windschitl (2002). In his research, he noted that the three participants who regularly used inquiry instruction in their teaching were those who had previous long-term research experiences in which they played significant roles in authentic investigations. Conversely, the two participants with no research experience did not use inquiry instruction in the classroom (pp. 138-139). Similarly, Eick and Reed (2002) found out that pre-service teachers who needed to experience doing science for them to learn science (i.e., learning science through inquiry) were more likely to use inquiry instruction in their lessons than pre-service teachers who learned science best through teacher explanations.

Clearly, if pre-service teachers are expected to implement an inquiry-based curriculum successfully, they must have the opportunity to experience "active learning strategies to engage their students in the process of science (Handelsman, as cited in Melville et al., 2008). They must be given a context in which they can develop their understanding of science as a subject and an understanding of the challenges they will encounter in using inquiry as a teaching strategy (Melville, et al., p. 479).

Pre-service Teachers' Self-efficacy to Teach Using IBSI

One crucial factor that determines the success of the use of IBSI among future science teachers is their belief in their capability to organize and execute such a strategy. This belief in one's ability is called self-efficacy (Bandura, as cited in Chichekian & Shore, 2016). Self-efficacy, which is related to the concept of self-confidence, can impact the amount of perseverance and effort an individual undertakes when working toward achieving an objective (Bandura, as cited in Chichekian & Shore, 2016, p.2). Self-efficacy can powerfully influence the choices individuals make and the courses of actions they pursue (Chichekian & Shore, 2016; Pajares, 1996). As such, self-efficacy is seen as a powerful predictor of a teachers' behavior and success in classroom teaching (Velthuis, Fisser, & Pieters, 2014). Self-efficacious teachers will tend to set higher goals, be less afraid of failure, and find new strategies when old ones fail.

The supporters of the concept of self-efficacy contend that it is not a one-dimensional construct. In reality, self-efficacy is commonly understood to be domain- and context-specific (Chichekian & Shore, 2016; Velthuis et al., 2014). Thus, the self-efficacy of teachers may vary within different subjects, such as in teaching mathematics or history. Moreover, within the domain of mathematics, teachers may

be self-efficacious in teaching algebra, but not statistics. Such domain and context-specific sense of self-efficacy does not apply only on the teaching of content, but also in the use of a teaching strategy.

According to Bandura (as cited in Chichekian & Shore, 2016; Roster, 2006; Velthuis et al., 2014), self-efficacy is influenced by four types of experiences: mastery experiences, vicarious experiences, social persuasions, and psychological and emotional states. Of these four, mastery experiences are most effective in creating a feeling of self-efficacy (Velthuis et al., 2014). By completing a task, the individual should feel more efficacious to complete other tasks of a similar nature (Roster, 2006). Vicarious experiences, on the other hand, are experiences or examples observed from others who are similar to oneself. As pre-service teachers observe experienced teachers deliver instruction, they acquire pedagogical skills and acquire the confidence to apply what is observed in practice.

One's personal ability to succeed at a given task, can also be enhanced by social persuasions – which are positive written or auditory feedback from a knowledgeable person, such as an instructor. Such positive remarks from a person of higher authority could instill a higher sense of efficacy on current or future tasks (Roster, 2006). The last factor that affects one's sense of self-efficacy in Bandura's list is affective (emotional and psychological) states. Indeed, moods, emotions, and physical states (e.g., empty stomach) can all affect one's sense of self-efficacy about a given task.

Aside from the four factors identified by Bandura, other authors identify subject matter knowledge as a source of self-efficacy. Science content knowledge is reported to predict science teaching self-efficacy (Rohaan, Taconis, & Jochems, 2012).

Some research has looked into how pre-service teachers assess their preparedness to use inquiry instruction in their teaching (Roth et al., 1998; Windschitl & Thompson, 2006). Roth and colleagues (1998) reported on pre-service teachers claiming that they are not prepared to incorporate inquiry instruction, even if they had taken science methods courses and held science degrees. Their samples were unable to engage with a scientific problem at a level higher than a group of eighth-graders that had been enrolled in a 10-week open inquiry study (Binns & Popp, 2013). These findings were supported by Windschitl and Thompson (2006).

In their study on whether or not Spanish pre-service primary school teachers are prepared to teach science by inquiry, Montero-Pau & Tuazon (2017) reveal that their respondents fail when they attempt to build a learning sequence based on inquiry. They noted further that their participants did not reverse the current situation in Spain, where the introduction of inquiry-based science in primary schools is rare or incipient. Moreover, the authors noted that these pre-service primary teachers have a lack of knowledge of science process skills. They scored slightly higher than the random group of non-teachers acting as a comparison group.

The difference between a teacher who allows more inquiry-based instructional time for a subject and one who does not could be related to self-efficacy (Smolleck & Mongan, 2011). The self-efficacy of pre-service and in-service teachers to implement inquiry-based instruction was explored by Chichekian & Shore (2016). Some general ideas that are expounded are as follows: (1) Self-efficacy has been correlated with teachers' beliefs about and willingness to improve methods of instruction using inquiry (Leonard, Barnes-Johnson, Dantley, & Kimber, 2011; Smolleck & Mongan, 2011), (2) Highly efficacious teachers attributed their high sense of teaching efficacy to their increased knowledge of teaching strategies,

among them inquiry, interactive, and hands-on learning (Swars Auslander & Dooley, 2010), and (3) Those with higher self-efficacy for teaching were more likely to be aware of various instructional approaches and were more open and willing to experiment with innovative approaches to promote autonomous learning among and better meet the needs of their students (Ross, Bradley Cousins, & Gadalla, 1996).

Some interesting trends arose from the fore-mentioned review. In the context of science education (Narayan & Lamp, 2010) and mathematics teaching (Cakiroglu & Isiksal, 2009), experienced teachers and those with high self-efficacy were more in favor of creating inquiry-based classroom environments. This high level of self-efficacy has been attributed to the continuous success in understanding the science content taught, learning different pedagogical techniques and practices, and being able to teach the science content learned to primary school children during teaching internship. In another study, elementary science teachers who are autonomous and professionally active have demonstrated higher self-efficacy for teaching inquiry than those driven by external motivators.

In contrast, it was found out that teachers with low-self-efficacy often avoid a particular subject matter (Enochs, Scharman, & Riggs, 1995). Also, several studies have described how beginning teachers with low general self-confidence for teaching (at both elementary and secondary levels) avoided using an inquiry approach. Instead, they resorted to the use of low-risk instructional activities such as textbook reading and using reading and writing-based strategies rather than on hands-on and minds-on activities.

Pre-service Science Teachers' Application of IBSI During Teaching Internship and Their Experiences

In the study on the experiences of pre-service teachers to teach using inquiry-based instruction, Binns and Popp (2013) noted that their pre-service teacher sample found it challenging to incorporate inquiry instruction in their classroom. This is despite the emphasis of inquiry instruction as a teaching approach in their teacher preparation programs and their positive view about inquiry instruction. There obviously is a disconnect between what the pre-service teachers believe in and in what they learn in teacher preparation courses with what they experience in their student teaching placements.

In a case study involving the use of inquiry-based instruction of three pre-service science teachers during teaching internship, Nuangchalern, Dostal, & Luo (2016) found that the participants differed in how they planned and conducted their lessons during their teaching internship teaching. They exhibited some key similarities that seemed to characterize their sense of making use of inquiry approaches. However, although some of the elements of inquiry-based instruction are seen in their lesson plans, the actual applications of these elements in actual teaching seem to be wanting. Participant 1, for instance, emphasized the 5E learning model in the lesson plan, but she did not emphasize on the process of inquiry during the actual presentation. She failed to work with questions, nor guide the students to empower their inquiring minds. Her classroom reflected the traditional, teacher-centered set-up, and she dominantly taught using worksheets (pp. 490-491).

The limited use of inquiry-based instruction during teaching internship experience could be attributed to several factors. The most important factor

identified in literature is that the pre-service teachers were themselves unlikely to have been taught with this strategy. The use of reformed teaching approaches such as inquiry could have conflicted with the apprenticeship they have experienced as students in secondary school settings. They, therefore, had minimal direct experience with the execution of inquiry instruction outside the methods course (Binns & Popp, 2013). In addition, the cooperating teacher with whom the pre-service teacher was paired may have used more traditional teacher-centered approaches over student-centered ones. This assumption is supported by Lotter (2004), who found out that in a group of pre-service teachers, most disagreed with their cooperating teacher's instructional methods" and wished to "see more inquiry-based instruction" (as cited in Binns & Popp, 2013). Indeed, when a pre-service teacher's core beliefs conflict with inquiry or constructivist practices, "they act as barriers in the development of constructive beliefs, almost despite their desire to put the constructivist beliefs into practice (Haney & McArthur, 2002).

Another barrier to the use of inquiry-based science education in teaching internships is that pre-service teachers are often concerned about adhering to the local curriculum and become focused on day-to-day survival, instead of putting into practice their beliefs about inquiry instruction (Gabrielle & Joran, 2007). These conflicts cause a mismatch between their idealization of inquiry instruction and what they are probably able to accomplish.

The fear of not being able to meet national mandates or standards and the feeling of incompetence pose a challenge when teachers consider committing to use inquiry-based instruction (Chichekian & Bruce, 2016). Because inquiry-based instruction is seen to be chaotic for young teachers to handle, many experience the fear of losing control of the learning environment. Also, because IBSI is a

constructivist and a student-centered approach, many teachers might feel that they are not covering the content they are expected to teach. Some pre-service teachers hold the wrong notion that they are compelled to teach using teacher-centered approaches as they are to showcase their mastery of the content they are to teach. Such is the case, aside from the prevailing tendencies of pre-service teachers to teach in the same way they are taught in their undergraduate courses.

A group of science teachers with limited inquiry experience and did not identify any inquiry exposure during their undergraduate degrees have identified time, curriculum, and materials as the significant barriers to the use of the teaching approach. Also, the reactions of students – frustration, reluctance, intimidation, and apathy – are the major impediments to the use of inquiry. Other issues impeding inquiry use are the negative reactions of parents, colleagues, and school personnel. The ability to plan developmentally suitable lessons, balancing inquiry with academic standards, and lack of resources were often provided as reasons for the non-implementation of inquiry-based science education (Melville et al., 2008; Smolleck & Mongan, 2011). In the case of pre-service teachers, lack of support from supervising teachers and cooperating teachers are the major barriers to their inquiry use.

To increase pre-service teachers' self-efficacy and tendency to use inquiry-based instruction, a total of 33 studies highlighted nine prior experiences that are necessary for this purpose. These specific examples reported in the studies were: (1) receiving extensive practice implementing inquiry instruction; (2) modeling inquiry instruction; (3) having research experiences during teacher education; (4) support from mentors for trying inquiry, such as from instructors and teaching internship teachers; (5) visiting inquiry classes in action; (6) experiencing out-of-school teaching sites such as museums and nature centers; (7) reflecting on past inquiry

experiences concerning planning instruction; (8) examining personal beliefs about learning and teaching and (9) having had earlier research experiences (Chichekian & Shore, 2016).

Need for the Study

Little is written about pre-service science teaching and their experiences or exposure to inquiry-based instruction, or how these pre-service science teachers are prepared to teach using these reformed teaching approaches in science. Such is especially the case among prospective science teachers in the Philippines. Most local related studies covered broader scopes in terms of context – content-wise or participant-wise. Examples of studies on pre-service teaching deal with more general themes such as their self-efficacy to teach the 21st-century skills (Balaan, 2016), or on how these pre-service science teachers deliver lessons during their teaching internship experience (Ulla, 2016). Some studies investigated the teaching efficacy of elementary teachers (Quinco-Cadosales, 2017). These broad approaches are likewise seen in studies involving pre-service science teachers, such as pedagogical-content knowledge, or technological-pedagogical content knowledge. The only research that is most related to this current endeavor is the one conducted by Gutierez (2015). Using the procedure of lesson study, the author explored how public elementary school science teachers in the Philippines enact inquiry-based instruction in their teaching. The study revealed three major challenges in the implementation of IBSI. These challenges include the lack of support, training and materials, overemphasis on content assessment, and the nature of inquiry itself. These challenges, incidentally, are consistent with international trends.

This study is worth investigating since the pre-service science teachers are the future implementers of inquiry instruction, and they are given the responsibility to bring the true essence of science to the next generation of Filipinos.

Notable among the few international studies on pre-service science teaching and inquiry-based instruction that documented the understanding and views about IBSI, or their self-efficacy to teach using the approach, is the non-linking of these constructs with the PSTs' actual application of IBSI in their student teaching experience. There was no attempt to correlate these constructs. Such a gap was addressed in this study.

This study also wishes to address the gap as to whether or not pre-service science teachers are exposed to IBSI practices during their pre-college, college, and field study experiences. The important question the researcher wants to answer is whether or not teacher-training institutions are properly equipping the science teacher education candidates with the knowledge and skills for them to teach science following science education reforms. Also, this study will shed light on the PSBTs' predisposition to teach using IBSI, and whether these predispositions translate into actual application during practice teaching. This important relationship was so far not extensively explored in literature. Finally, this study wishes to explore the moderating effect of the PSBTs' educational philosophies and on their self-efficacy and predisposition to teach using IBSI, and their actual application of this teaching approach in their teaching internship experience.

Conceptual Framework

The responsibility of sowing the seeds of inquiry-based science instruction on future science teachers lies more on science education professors, not on teacher-education professors (Pushkin, 2001, cited by Buck *et al.*, 2008). This view is

supported by Winchschitl and Thompson (2006), who stated that science teacher educators are the agents to model inquiry practices for pre-service science teachers. However, both teacher educators and science educators must be conscious of their responsibility for sowing the seeds of inquiry in the minds of these future teachers.

The successful implementation of IBSI in science teaching depends on several factors. These factors might include the PSBT background, exposure, or experiences with such teaching methods throughout all science classes (Binns and Popp, 2013), and even methods courses (Buck et al., 2008). This claim is supported by a popular adage in education, which says one cannot teach or implement what he/she does not know.

Another factor that could influence the use of inquiry-based instruction could be the degree by which the pre-service teachers understand the nature of inquiry. Related to exposure or background, one cannot implement a teaching strategy that one does not fully understand. Bybee (2000) explained, "To develop good inquiry-based science teaching, teachers need to understand the precise nature of inquiry, and also need to have sufficient knowledge of the discipline itself." However, as noted by Llewellyn (2002) and Gutierez (2015), teachers have many misconceptions and myths about inquiry-based science teaching. Such issues could have been confounded by the fact that even the term inquiry has multiple and no exact definitions (Buck, Bretz, & Towns, 2008). Such a dilemma would certainly affect how educators and pre-service teachers expound and understand inquiry-based learning as a teaching strategy. In turn, their understanding and application of the strategy could be compromised.

The successful implementation of IBSI may also be influenced by the pre-service teacher's attitude toward a teaching strategy (Uredi, 2013). Attitude, after

all, is a powerful predictor of future behavior (Xie & Tariff, 2014). Attitudes are opinions or general feelings one holds on something, and they have a great influence on how successful people are in attaining higher outcomes (Cole & Levine, 2000). These attitudes affect how a person uses or does not use (or even forgets) a certain skill or methodology. Attitudes can be closely tied to motivation within a subject, and typically correlate to achievement. So, it can be assumed that the more positive the PSTs' attitudes toward the IBSI, the higher their tendencies to apply such a strategy (Sherman & Fazio, as cited in Frymier & Nadler, 2017).

These attitudes towards a teaching approach, method, or strategy can, in turn, be based on one's educational philosophy (Sadker & Sadker, 2003). According to Austin & Reinhardt, as cited in Melehat Gezer (2018), educational philosophy is influential in gauging prospective teachers' perceptions, decisions on curricula and teaching practices, and behaviors and practices in the classroom. Thus, the pre-service teachers who are more inclined to the learner-centered educational philosophies would tend to be oriented toward learner-centered pedagogical approaches, such as IBSI.

Another factor that could influence the application of IBSI by pre-service teachers might be their self-efficacies. The role self-efficacy on ones' capacity to implement a strategy also plays an important role in the actual use of that teaching strategy. If teachers believe that they can implement a strategy without much difficulty, then it is no doubt that they will use such strategy in their teaching, either at will or when asked (Chichekian & Shore, 2016; Swars Auslander & Dooley, 2010; Velthuis et al., 2013). Also, the predisposition to teach a certain strategy could be related to one's actual application of such a strategy.

In this study, the interrelationships among the variables were explored. The interrelationships among PSBTs' IBSI exposure during their pre-college science and college science, and field study courses and their IBSI understanding, attitude, self-efficacy, predisposition, and applications during interrelationship were explored. Also, the interrelationships were explored among overall IBSI exposure along lesson planning and implementation, content knowledge, and classroom culture and the other IBSI variables. These procedures were done to provide a more extensive picture of the factors that influence the PSBTS' enactment of IBSI.

The interrelationships among the other IBSI variables and their elements or components were also explored. Learner-centered views were also included in the exploration of interrelationships.

The variables IBSI exposure, IBSI self-efficacy, and IBSI application included three elements: lesson planning and implementation, content knowledge, and classroom culture. Meanwhile, the elements under IBSI understanding and IBSI predisposition included the three phases of a lesson – lesson beginning, lesson proper, and lesson ending. The elements under IBSI attitudes are the three dimensions of attitudes – liking, interest, and perceived usefulness and learner-centered views. Finally, the learner-centered views included constructivism, progressivism, and social reconstructionism as its elements.

The interrelationship among the variables is shown in the conceptual framework of the study in Figure 1.

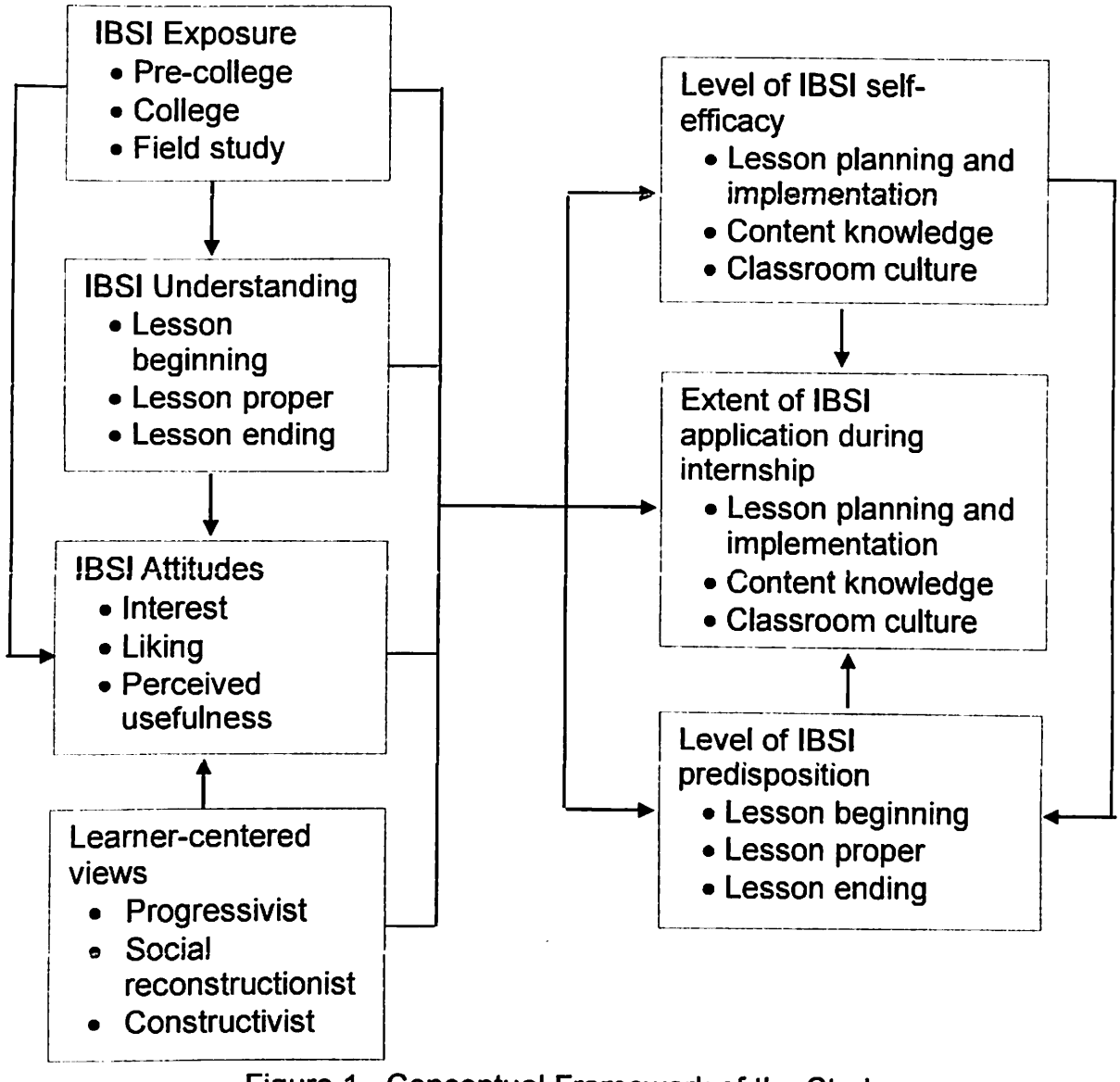


Figure 1. Conceptual Framework of the Study

Research Hypotheses

The research hypotheses of the study were as follows:

H_a1: The following variables, taken singly, are significant predictors of the PSBTs' IBSI self- efficacy:

a) IBSI exposure,

b) IBSI understanding,

c) IBSI attitudes,

d) and learner-centered views;

H_a2: The following variables, taken singly, are significant predictors of the PSBTs' extent of application of IBSI during their teaching internship experience:

a) IBSI exposure,

b) IBSI understanding,

c) IBSI attitudes,

d) learner-centered views,

e) IBSI self-efficacy,

f) and IBSI predisposition;

H_a3: The following variables, taken singly, are significant predictors of the PSBTs' level of IBSI predisposition:

a) IBSI exposure,

b) IBSI understanding,

c) IBSI attitudes,

d) learner-centered views,

e) and IBSI self-efficacy;

H_a4: The PSBTs' IBSI exposure is a significant predictor of their IBSI understanding.

H_a5: The following variables, taken singly, are significant predictors of PSBTs' IBSI attitudes:

a) IBSI exposure,

b) IBSI understanding,

c) and learner-centered views;

H_a6: The following variables are significantly correlated:

a) IBSI exposure,

b) IBSI understanding,

c) IBSI attitudes,

d) learner-centered views,

f) IBSI self-efficacy,

g) IBSI predisposition,

h) and extent of IBSI application during teaching internship.

Definition of Terms

Classroom culture. This is one of the three elements of IBSI that was used to describe the PSBTs' IBSI exposure during pre-college, college, and field study courses, IBSI self-efficacy, and IBSI application during internship. It particularly refers to the aspect of IBSI that involves communicative interactions and student/teacher relationships.

Content knowledge. In this study, content knowledge is another IBSI element that was used to describe the PSBTs' IBSI exposure, self-efficacy, and application during internship. Content knowledge refers to the aspects of IBSI dealing with the development of the learners' propositional and procedural knowledge, including metacognitive knowledge.

Inquiry-based instruction (IBI). This study used the term inquiry-based instruction as synonymous with inquiry-based learning, or inquiry instruction. IBI is a learner-centered, constructivist approach in teaching. It is one of the teaching approaches advocated by the science education standards in most parts of the world, including the Philippines. It is believed that IBI promotes the learners' attainment of scientific, technological, and environmental literacy (DepEd, 2012). More than a "hands-on" approach, it emphasizes a "hands-on-minds-on" learning experience.

Inquiry-based science instruction (IBSI). This term was used to refer to the application of the principles of inquiry-based instruction (IBI) in the teaching and

learning of science in all levels of education. Most of the IBSI descriptions of Llewellyn (2013) were used in this study.

IBSI attitude. IBSI attitude is one of the PSBTs' IBSI variables investigated in this study. Measured by the Attitude Scale for IBSI Use (ASIU), it determines whether or not the PSBTs' favor the practices and classroom applications of IBSI. The PSBTs' IBSI attitudes were then categorized into the attitude dimensions of interest, liking, and the perceived usefulness of the strategy.

IBSI application. This is another IBSI variable of interest in this study. IBSI application refers to the manner, extent, or degree by which the PSBTs implement IBSI principles and practices during their teaching internship. This variable was measured by the PSBTs' self-assessment and by their cooperating teachers' observation ratings.

IBSI exposure. This study also explored the PSBTs' exposure to IBSI. IBSI exposure was used to profile the experiences of the PSBTs with inquiry-based science instruction. This variable was measured with an instrument that required the PSBTs' to recall and rate the extent of their IBSI experiences during pre-college, college science courses, including their field study observation courses.

IBSI predisposition. IBSI predisposition was another variable of interest in this study. IBSI predisposition was used to describe the PSBTs natural tendencies to choose inquiry-based instruction instead of direct instruction models in their future teaching. IBSI predisposition was measured in this study by an instrument involving simulated teaching scenarios followed by options depicting inquiry and non-inquiry teaching.

IBSI self-efficacy. This explored IBSI variable refers to the PSBTs' self-confidence, or belief that they can successfully implement IBSI principles and

practices in the present or the future. The PSBTs' IBSI self-efficacy was determined by an instrument that required the respondents to rate their confidence in implementing specified IBSI practices using a 10-point scale.

IBSI understanding. This IBSI variable was used in the study to refer to the PSBTs' ability to distinguish the principles and practices of IBSI, whether guided or open inquiry, against the direct instruction methods (such as lectures or demonstrations). This IBSI understanding was gauged by asking the PSBTs to choose the options that depict IBSI practices in the Biology section of the Pedagogy of Science Teaching Test (POSTT).

Learner-centered views. This variable was measured using the scores that the PSBTs got in a standardized educational philosophy self-assessment instrument of Cohen in 1999. They determined the PSBTs' level of learner-centered views categorized as progressivism, constructivism, and social reconstructionism defined as follows:

Constructivism. Constructivism is one of the three -learner-centered views explored in this study. Based on the work of Cohen (1999), this study describes constructivism as an active learning approach where the learners construct their understanding of reality through acting upon and reflecting on their experiences in the world. The role of teachers in a constructivist classroom is to facilitate environmental conditions and mediate learning experiences.

Progressivism. This study adopts how Cohen (1999) and Sadker and Sadker (2003) describes this educational philosophy. According to Cohen, "progressivism believes that education should focus on the child rather than the subject matter. Learners are seen as active in solving problems by

experimenting and reflecting on their experience" (p. 8). Sadker and Sadker added that in progressivism, "the role of schools is to help students develop personal and social values so that they become thoughtful and productive citizens" (p. 112).

Social reconstructionism. Again, Cohen's description of this educational philosophy was adopted in this study. This educational philosophy advocates that "schools should take the lead to change society in order to create a better world. Social reconstructionist teachers use critical thinking skills, inquiry, questioning, and action as teaching strategies. Here, students learn to handle controversy and to recognize multiple perspectives" (Cohen, 1999).

Lesson planning and implementation (LPI). LPI is another IBSI element used to provide a detailed description of the PSBTs' IBSI exposure, self-efficacy, and application during internship. This element particularly refers to the stage where an IBSI lesson is conceptualized and planned, until its enactment in an actual science class.

Pre-service biology teachers (PSBTs). These are the main participants in this study. They are senior biological science education students from Baguio City and Benguet who are currently in or have completed their teaching internship experience.

Teaching internship. Teaching internship refers to the practicum stage that culminates all teacher-preparation programs in the Philippines. It is the stage where the PSBTs IBSI application was determined. This stage is also called student teaching, practice teaching, practicum, or teaching practice

Chapter 3

METHODOLOGY

This chapter is organized into four sections: (a) discussion of the research design; (b) characterization of the locale and participants of the study; (c) description of the research instruments and procedures; and (d) the procedure for data analysis.

Research Design

This study used both qualitative and quantitative methods of research. In particular, survey, *ex – post facto,* or causal-comparative and correlation procedures were employed.

The survey method was used to collect most of the major data needed to answer the research questions. The PSBTs' lesson plans were likewise analyzed to validate the quantitative results. Interviews and focus-group discussions were employed to triangulate the data collected.

Locale of the Study

The study was conducted in Baguio City and Benguet province on three teacher-training institutions (TEIs) offering specializations in the biological sciences. These TEIs were recently designated as Centers of Excellence or Centers of Development in teacher education by the Philippine Commission on Higher Education (CHED). The deans of these TEIs responded positively to the researcher's request that their students be involved in the study as participants.

One of the case institutions is the Benguet State University – La Trinidad Campus (BSU-LTC), located in Benguet's capital town of La Trinidad. The institutions' College of Teacher Education holds the distinction as one of CHED's centers of excellence in its secondary education program. The college currently

holds Level III accreditation from the Philippine Association of State Universities and Colleges.

The second case institution is the Saint Louis University (SLU), a private sectarian university that holds the distinction of having the highest number of student enrolment in all schools north of Manila. Its secondary education program is likewise one of CHED's centers of excellence in teacher education and is Level III accredited by the Philippine Accrediting Association of Schools, Colleges, and Universities.

The third institution is the University of Baguio (UB), a private non-sectarian university that remains the third largest university in the Cordillera region in terms of student enrolment. Its secondary education program currently enjoys the center of development distinction from CHED. The program likewise is granted Level IV Re-accredited status by the Philippine Association of Colleges and Universities Commission on Accreditation.

There are unique schemes for science education in these case institutions. In BSU-LT and UB, biology courses are not taught in the College of Teacher Education. They are instead taught in the College of Science or the College of Allied Medical Sciences (Medical Technology or Dentistry). However, in BSU-LT, the biological sciences students are handled as a single class, unlike in UB, where the students are mixed with the students from other degrees related to the biological sciences. Meanwhile, in SLU, most biology courses are taught by teachers in the College of Education, or by some adjunct faculty members in the College of Science who hold a teacher's license. This practice in SLU is according to an existing CHED requirement for science education programs.

Participants of the Study

The participants of the study were 66 pre-service Biology teachers who have finished two semesters of teaching internship during the academic year 2017-2018. Forty-one of these participants came from Benguet State University – La Trinidad Campus (BSU-LT), while 12 and 13 participants were from Saint Louis University (SLU), and the University of Baguio (UB), respectively. More participants came from BSU – LT because they belong to the regular cohorts of students. The participants from SLU and UB do not belong to the regular cohort.

Before taking part in the study, a consent form indicating the purpose of the study and the voluntary nature of their participation was signed by the participants. The cover letter of the consent form is shown in Appendix B. All pre-service biology teachers from BSU-LT voluntarily participated in the study. Meanwhile, in both SLU and UB, one PSBT each either opted not to participate or was absent during the data-gathering. Since the participants' ages ranged from 19 to 22, no parental consent was required. Moreover, the participants' consents were solicited for the researcher to gather information about their teaching performance during internship from their cooperating teachers.

As per institutional policy, SLU and UB allow their pre-service teachers to teach in both junior and senior high schools, while BSU-LT deploys its interns only in junior high schools. As they teach in both junior and senior high schools, the PSBTs are given teaching loads not only in the biological sciences but also in the other science fields. This practice has become the norm as the Philippine basic education has shifted to the interdisciplinary, spiral progression approach.

Research Instruments

Instrument used to measure the PSBTs' IBSI exposure. The Science Teachers' Inquiry Practices Scale (STIPS, Appendix D) was used to determine the PSBTs' IBSI exposure during their pre-college science, college science, and field study courses. The instrument was based on the Characteristics of an Inquiry Classroom (CIC) identified by Llewellyn (2013). The STIPS is a 30–item observation or evaluation tool used to assess the participants' perceptions of how their former subject and cooperating teachers employed IBSI practices in teaching.

The items were clustered into three elements based on the clustering identified in the Reformed-Teaching Observation Protocol [(RTOP); (Sawada, Sawada, Falconer, Turley, Belford, & Bloom, 2002)]. The cluster names, number of items, and the internal consistencies of the items are presented in Table 1. The items were pre-tested to 229 science education majors who were not involved in the study. These are the science education majors who recently graduated or those who are in the lower years.

Table 1. Structure and reliability of the Science Teachers' Inquiry Practices Scale (STIPS)

Elements	Name	No. of items	Item placement	α
1	Lesson planning and implementation	9	4, 5, 6, 7, 8, 12, 13, 21, 22	.886
2	Content knowledge	12	2, 9, 14, 16, 17, 18, 20, 24 ,25, 26, 29, 30	.960
3	Classroom culture	9	1, 3, 10, 11, 15, 19, 23, 27, 28	.875
Overall				.961

As shown in Table 1, the overall and component internal consistency of the instrument is very high at r = .961, indicating that the items are homogeneous. Using an online readability calculator (Readabilityformulas, nd) that reports results from eight different tools, the instrument is suitable for students whose ages range from 14 to 15, who are approximately in Grade 10. Although the instrument is labeled as

difficult to read, the recommended age and grade levels are younger than the target participants of this study. Finally, the mean of participants' ratings of their IBSI exposure from pre-college, college, and field study courses were obtained to determine their overall level of exposure on this teaching approach.

All items in the STIPS are declarative statements about inquiry use, as described in literature (Llewellyn, 2013). The scale was answered using a five-point scale, described and interpreted as follows:

Table 2. Scale, description, and interpretation of the responses to the STIPS

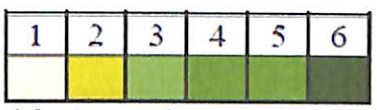
SCALE	FREQUENCY OF OCCURRENCE	INTERPRETATION
1	1% - 20% of the time	Very Limited (VL)
2	21% - 40% of the time	Insufficient (InS)
3	41% - 60% of the time	Moderate (M)
4	61% - 80% of the time	Sufficient (S)
5	81% - 100% of the time	Extensive (E)

Instrument used to measure the PSBTs' IBSI understanding. The level of the PSBTs' understanding of IBSI was assessed quantitatively using the biology items in the Pedagogy of Science Testing Test (POSTT-B), developed and validated by Cobern, Schuster, Adams, Skjold, Mugaloglu, Bentz, & Sparks (2014). The POSTT-B is in Appendix E. The PSBTs' ability to identify the options involving IBSI principles in the POSTT-B indicates their level of understanding of IBSI. The Mallinson Institute for Science Education of the Western Michigan University, from which the instrument developers are based, is granting permission to science educators and researchers for the use of the instrument. The developers of the instrument even encourage interested parties to use the instrument as a summative assessment tool, as the POSTT is originally intended for formative assessment. Furthermore, the readability levels of the items are within the standard/average

reading level. It is suitable for Grade 7 learners, with ages from 13 to 14 (Readabilityformulas, n.d.).

The original POSTT has four versions, composed of items from earth and space science, biology, chemistry, and physics. Only the Biology items of the test were used in the study to eliminate content-related bias. Each of the 16 items in the POSTT contains a classroom vignette followed by response choices carefully crafted to include four basic pedagogies (didactic direct, active direct, guided inquiry, and open inquiry). There are items involving how to begin, teach, or end a science lesson. A sample item in the POSTT is given as follows:

(8) Photosynthesis



Ms. Hamid has been teaching her 8th-grade students about photosynthesis, and in particular, that chlorophyll production in plant leaves is light-induced. She sets up an example to illustrate this. She has placed fast-growing seedlings where they are exposed to different levels of light intensity. The students observe the growing plants over several days and estimate the amount of chlorophyll using a color chart to record leaf color. They record their data in their science notebooks and on a classroom data table. On the last day, Ms. Hamid reviews the role of light in chlorophyll production, as illustrated by the activity.

Thinking about how you would teach this topic, of the following, which is the best evaluation of her lesson?

A. This is a good lesson design overall because Ms. Hamid begins with an explanation of the concepts that she wants the students to learn, followed by an activity for students to confirm that chlorophyll production is light-induced. (Active direct)

B. Ms. Hamid begins appropriately with an explanation of the concepts she wants the students to learn. This being so, it is not clear that the activity is needed, especially since it requires so much class time. (Didactic direct)

C. Ms. Hamid's approach is too pre-organized and prescriptive. It would be better for students themselves to decide how to set up plants and lights, see what happens, and figure out a way to compare chlorophyll production in the leaves. (Open inquiry)

D. The instructional sequence would be better if the students do the plant observations first, showing that chlorophyll is light-induced, after which Ms. Hamid can explain the process more fully. (Guided inquiry)

In a way, the PSBTs' levels of IBSI understanding were gauged in their ability to distinguish which among the choices manifest IBSI practices. The PSBTs were asked to identify the choice or choices that manifest the principles of IBSI, either in the form of guided inquiry or open inquiry. They were informed that there could be more than one answer per item, but they were penalized for every wrong option that they chose. The items were scored based on whether or not the participants identified the options that characterize IBSI principles. Hence, since each item has two options that manifest IBSI (guided and open inquiry), the maximum points per item were awarded. One point was awarded if a participant picked only one correct option. The right minus wrong scoring scheme was used. For instance, if a participant provided two answers in an item, where one answer is correct and the other wrong, then no point was given for that item. If two wrong options were selected, then the participant was given negative 2 points. Thus, scores in the POSTT-B can range from a minimum of below zero to a maximum of 32 points.

The participants' level of understanding about IBSI was determined based on their scores in the POSTT-B. The following scale was used to interpret their level of understanding:

Table 3. Interpretation of mean scores in the POSTT-B used to gauge IBSI understanding

MEAN SCORES	INTERPRETATION
0.00 or lower	Very Limited
0.01 – 0.50	Limited
0.51 - 1.25	Moderate
1.26 - 1.75	Sufficient
1.76 - 2.00	Extensive

As a validating procedure, the PSBTs were asked to give their definition of IBSI and to describe their best experiences with the approach. The quality of their definitions and descriptions were analyzed and reported in the results section.

Instrument used to measure the PSBTs' IBSI attitude. To determine the PSBTs' attitudes toward IBSI, the Attitude Scale for IBSI Use (ASIU), adopted from Evrekli, Inel, Balim & Kesercioglu (2010), was used. The ASIU instrument is found in Appendix F.

Of the 14 items in the ASIU, 11 were positively stated, while four were stated in the negative. When the readability level of the instrument was entered on an online readability analyzer, the readability consensus revealed that the instrument is "fairly easy to read, suitable for readers ages eight to nine."

The ASIU instrument measures three dimensions of attitude (Evrekli et al., 2010). The attitude dimensions being measured and the corresponding number of items are as follows: a) interest (five items), b) liking (four items), and perceived usefulness (five items).

The items in the ASIU were answered with Yes, Somewhat, or No. The responses were then scored following the manner of scoring attitude scales described in literature (Gronlund & Keith – Waugh, 2009; Popham, 2011). Two points were awarded for a positive response to a positive statement, and negative two was given for a positive response to a negative statement. Conversely, two points were awarded for a negative response given to an item stated negatively, and negative two were awarded for a positive response to a negatively stated item. A somewhat answer to a positive statement received a score of one, while a somewhat answer to a negative statement received a negative one. With this scoring scheme, the highest possible score in the ASIU is 44, and the lowest is -44.

The PSBTs' attitudes toward inquiry use were gauged based on their scores in the ASIU. The scores were then interpreted using the scale shown in Table 4.

Table 4. Interpretation of the scores in the ASIU used to gauge IBSI attitudes

MEAN SCORE RANGES	TOTAL SCORE RANGES	INTERPRETATION
0 and below	0 and below	Very low (VL)
0.01 to 0.50	1 – 7	Low (L)
0.51- 1.25	8 – 16	Moderate (M)
1.26 -1.75	17 – 23	High (H)
1.76 – 2.00	24 – 28	Very high (VH)

Instrument used to measure the PSBTs' learner-centered views. The PSBTs' learner-centered views (LCV) were assessed using the educational philosophy self-assessment scale (EPSAS) developed by Cohen (1999). The original scale included eight educational philosophies, but only the items under perennialism, essentialism, behaviorism, progressivism, social reconstructionism, and constructivism were used as the other items are more of psychological views and not strictly educational philosophies (Sadker & Sadker, 2003). The first three educational philosophies were predominantly teacher-centered, while the remaining ones were student-centered philosophies (Parkay & Stanford, 2007; Sadker & Sadker, 2003). The revised instrument is in Appendix G.

While the participants' teacher-centered philosophical views were also taken, it was done simply to compare these views with their learner-centered views. Only the PSBTs' learner-centered views were presented and analyzed in this study since IBSI is basically a learner-centered teaching approach.

Instrument used to measure the PSBTs' self-efficacy to teach using IBSI. The PSBTs' self-efficacy for IBSI was determined using the Inquiry Use of Self-Efficacy Scale (IUSES), which was adapted from literature (Appendix H). The items in the IUSES were based on Isola and Wenning's (2007) Inquiry-Based (Reformed)

Teaching Self-Assessment Inventory (ITSAI). The ITSAI, in turn, was a modification of the Reformed-Teaching Observation Protocol (RTOP) developed by Sawada et al. (2002).

The RTOP is a formal and structured observation method designed for trained observers to score a videotaped lesson. It is a 25-item classroom observation protocol that is (a) standards-based, (b) inquiry-oriented, and (c) student-centered (Sawada et al. 2002). The scores are then used as a way to measure the amount of "reformed teaching" that is occurring in a classroom. The RTOP has a high level of reliability (Cronbach α for the whole test is 0.97, interrater reliability estimate = 0.95) and validity and provides education researchers a way to compare the effectiveness of various teaching practices and to correlate such practices with student achievement (p. 247). The RTOP provides an operational definition of what is meant by "reformed teaching." The items arise from research-based literature that describes inquiry-oriented standards-based teaching practices in mathematics and science" (Sawada et al. 2002).

The ITSAI, meanwhile, is a simplified version of the RTOP. It is modified to make it more of a guide for personal reflection of one's teaching. The idea was to change the focus of each item to direct it inward and to change the terminology to describe the same characteristics it was designed to measure in more common everyday terms (Isola & Wenning, 2007).

Table 5 illustrates the similarity among the items in the three instruments.

Table 5. Comparison of the sample items in the RTOP, ITSAI, and the IUSES

RTOP	ITSAI	IUSES
1. The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	1. My instructional strategies and activities show respect for students' prior knowledge and their preconceptions or misconceptions found within that knowledge.	1. I CAN use strategies and activities that show respect for students' prior knowledge and their preconceptions or misconceptions found within that knowledge.
2. The lesson was designed to engage students as members of the learning community.	2. My lessons are designed to engage students as members of a "learning community," intellectual rigor, constructive criticism, and the challenging of ideas are valued.	7. I CAN design lessons that engage students as members of a "learning community," intellectual rigor, constructive criticism, and the challenging of ideas are valued.
3. In this lesson, student exploration preceded formal presentation.	2. In my lessons, student exploration precedes formal presentation.	3. I CAN provide opportunities for students to explore first before they are provided with formal presentation (lecture or demonstration, etc.)

The structure of the IUSES is shown in Table 6.

Table 6. Structure of the IUSES used to measure IBSI self-efficacy

Elements	Name	No. of items	Item placement	α
1	Lesson planning and implementation	8	1, 2, 3, 4, 5, 6, 7,17	.885
2	Content knowledge	9	8, 9, 10, 11, 12,13,14, 15, 16	.905
3	Classroom culture	7	18, 19, 20, 21, 22, 23, 24	.878
Overall instrument				.956

The levels of self-efficacy were determined based on the PSBTs' scores on the scale. Mean scores were obtained per participant, and their self-efficacy were interpreted following the scale shown in Table 7.

Table 7. Interpretation of the scores in the IUSES used to gauge IBSI self-efficacy

SCALE	MEAN SCORE RANGES	INTERPRETATION
1 – 2	1.00-2.49	Very low (VL)
3 – 4	2.50-4.49	Low (L)
5 – 6	4.50-6.49	Moderate (M)
7 – 8	6.50-8.49	High (H)
9 – 10	8.50-10.00	Very High (VH)

Instrument used to measure the PSBTs' predisposition to teach using IBSI. In determining the PSBTs' predisposition to teach using IBSI practices, the researcher developed and used the Test for Inquiry Pedagogy in the Science of Biology (TIPS-B) (see Appendix I). The TIPS-B was content-validated by three experts. One of the validators was a professor/research director at a State University. He holds a Ph.D. in Biology Education and teaches Educational Measurement and Evaluation in both the undergraduate and graduate levels. The second validator Ph.D. in Science Education degree holder with a Master's degree in Science education. She is currently a biology and science education professor in the largest private sectarian university north of Manila. The third validator is a retired professor in Biology and science education. She obtained a Ph.D. in science education major in Biology and a national board member in the largest national organization for biology teachers. All content validators had specialized in either Biology or Biology Education at the undergraduate levels.

The comments and suggestions were incorporated based on a consensus that if two out of three agreed on such suggestions, then these suggestions were incorporated into the instrument. There was one suggestion that some items should be shortened, but the other two did not agree as shortening the item might reduce the ability of the item to picture the situation desired to be analyzed. Another evaluator suggested that one option appeared to be an inquiry situation, but the two other evaluators did not agree. Since there was no consensus on the suggestions, the instrument was used as it was, except on some minor corrections on grammar and syntax.

The TIPS-B consisted of 15 classroom vignettes involving Biology teaching. Each vignette is followed by four options depicting teaching strategies with one or

two inquiry-based science instruction (IBSI), and two or three non-inquiry strategies. For items with two options manifesting IBSI, one option involved open inquiry, and another option depicted guided inquiry. This variation was done in the attempt to eliminate some answers that appear quite obvious. Also, the non-inquiry items were crafted in such a way that they manifest more active direct pedagogies, rather than passive, didactic direct instructional models. The TIPS-B was tried out with biology teachers, and biology education graduates and undergraduates in three different universities. This procedure was done to determine if all options are all attractive by attracting at least 5% of those who will answer the instrument. The results favored the affirmative, so the instrument was adopted in the study.

The readability of the instrument was likewise determined to ensure its reading ease. Using the online readability calculator Readabilityformulas.com (nd), the instrument is in the average or standard reliability level and is suited for Grade 8 learners, with ages ranging from 12 to 14.

To accomplish the instrument, the PSBTs chose among the four options the strategy they will most likely use when they teach a given Biology lesson. Their answers were scored, depending on whether or not they chose the options that manifested the IBSI practices. The PSBTs were given no points if they chose an option that is a non-IBSI, and one point was awarded when they chose any of the options that manifest IBSI. With this scoring scheme, the highest possible score was 15, and the lowest score was zero. The participants' scores were used to indicate their predisposition to teach using IBSI practices. The scores in the TIPS-B were as interpreted as follows:

Table 8. Interpretation of the scores in the TIPS-B used to gauge IBSI predisposition

MEAN SCORE RANGE	TOTAL SCORE RANGE	INTERPRETATION
0.00 – 0.15	0 – 2	Very low (VL)
0.16 – 0.35	3 – 5	Low (L)
0.36 - 0.65	6 -10	Moderate (M)
0.66 – 0.85	11- 13	High (H)
0.86 – 1.00	14 – 15	Very High (VH)

Instrument used to measure the PSBTs' application of IBSI during teaching internship. Finally, to assess the PSBTs' extent of application of IBSI in teaching, the modified Reformed Teaching Observation Protocol (mRTOP), and the modified inquiry-based teaching self-assessment inventory (mITSAI) were used. As earlier illustrated, the RTOP and the ITSAI contain similar items, except that the former is designed for observers in a teaching-learning process, while the second is designed as a self-assessment tool (Isola & Wenning, 2007; Sawada et al., 2002). The mRTOP was accomplished by the PSBTs' cooperating teachers near the culmination of the former's teaching internship experience. The mITSAI, on the other hand, was accomplished by the PSBTs at the culmination of their student teaching experience.

Before the cooperating teachers (CTs) accomplished the mRTOP, they were told to assess their biology student teachers as objectively as they could as their ratings would not be included in the student teachers' grades. For confidentiality, the CTs were asked to place the accomplished questionnaires in a sealed envelope. The CTs' ratings in the mRTOP were combined with the PSBTs' self-assessments in the mITSAI. The scores were then averaged to provide a more valid assessment of the PSBTs' use of inquiry-based instruction in their science classes. The mRTOP and the mITSAI are in Appendix J and Appendix K, respectively.

Both the mRTOP and the mITSAI are 23-item instruments. Each item in both instruments was answered on a scale of 0 (not true of me) to 4 (true of me on a regular basis). The level of application of IBSI during teaching internship was interpreted based on the obtained scores as follows:

Table 9. Interpretation of the combined ratings in the mRTOP and the mITSAI used to gauge IBSI application during teaching internship

SCALE	MEAN RANGE	FREQUENCY OF OCCURRENCE	EXTENT OF APPLICATION
0	0.00-0.49	Never	Very Limited (VL)
1	0.50-1.49	Seldom	Insufficient (InS)
2	1.50-2.49	Sometimes	Moderate (M)
3	2.50-3.49	Often	Sufficient (S)
4	3.50-4.00	Very often	Extensive (E)

Furthermore, to validate the quantitative results, the PSBTs' lesson plans were analyzed for some manifestation of IBSI use.

Data Analysis Procedure

Both descriptive and inferential statistics were used in the treatment of the quantitative data gathered. As for the IBSI variables that were measured using Likert-type items (IBSI exposure, attitude, self-efficacy, and application, including learner-centered views), the data gathered in both the overall and the components or elements were the composite scores. Hence, these data were in the interval scale. This action justifies the adoption of the parametric statistics procedures instead of its non-parametric equivalents in the analysis of data.

According to Clason and Dormody, (1994), "a Likert scale is composed of a series of four or more Likert-type items that are combined into a single composite score or variable during the process of data analysis. The combined items are used to provide a quantitative measure of a character or a personality trait. The researcher is only interested in the composite score that represents the character/personality

trait." (p. 12). From this initial work, Boone and Boone (2014) explained that the data obtained from Likert-type scales could be analyzed at the interval measurement scale, since a composite score (sum or mean) from four or more type Likert-type items were computed and utilized.

Other justifications for the adoption of parametric statistics despite the use of Likert scales are the works of Norman (2010), Rickards, Magee, and Artino (2012), and Sullivan and Artino (2013). For his part, Norman (2010), a leading figure in medical education research methodology, has comprehensively reviewed the controversy and provided compelling evidence, with actual examples using real and simulated data, that parametric tests can be used with ordinal data. Meanwhile, Rickards et al., (2012), remarked that researchers in the field of education and medicine commonly create several Likert-type items, group them into a "survey scale," and then calculate a total score or mean score for the scale items. This practice, according to and Sullivan and Artino (2013), particularly recommended when "researchers are attempting to measure less-concrete concepts, such as trainee motivation, patient satisfaction, and physician confidence - where a single survey item is unlikely to be capable of fully capturing the concept being assessed." (p. 2).

The normality of the data and the equality of the variances were likewise ascertained to justify the use of parametric tests. Using the Shapiro-Wilk test, which is considered the most powerful test for normality (Gashemi & Zahediasl, 2012; Peat & Barton, 2005), and the Levene's test for the normality of variance, all the Likert scales data were able to satisfy the normality assumptions at $p = 0.05$. All the obtained p-values in both tests were higher than $\alpha = 0.05$. Thus, parametric tests

were used in the analysis. The result of the Shapiro-Wilk test and Levene's test are shown in Appendices O and P, respectively.

With the above justifications, the data were thus summarized using means and standard deviations. Further, one-way analysis of variance (One-way ANOVA) at $p = 0.05$ level. If applicable, Tukey's HSD was used to determine significant differences along the subscales or elements of the IBSI variables.

Pearson-Product Moment Correlation (PPMC) was used to determine the inter-correlations among the IBSI variables. Finally, simple linear regression procedures were employed to determine if significant linear relationships exist among the IBSI variables and their elements. All data were run using the statistical package for the social sciences (SPSS) version 20. Meanwhile, the normality and equality of variances were tested using the statistics kingdom (staskingdom.com, nd), a statistics calculator on-line.

Chapter 4

RESULTS AND DISCUSSION

This chapter covers the findings of the study and the explanations and inferences the author made on these findings. Some of the findings were likewise corroborated with the results of previous studies.

Characteristics of the Pre-service Biology Teachers (PSBTs) According to their IBSI-related Attributes

PSBTs' IBSI exposure. The PSBTs believe that they bring a sufficient level of exposure to inquiry-based science instruction going into off-campus practice teaching (Table 10). This finding is based on their assessment of their experiences with IBSI practices during their pre-college, college science, and field study courses, using a scale that ranges from one (lowest) to five (highest). This result implies that the science teachers and professors who taught them have "often" used inquiry-based practices in their science teaching. This result further implies that, in the mind of the respondents, inquiry instruction practices are very much alive in the Philippines, even though the respondents in this study are products of the pre-science education reform era.

Table 10. IBSI exposure of the PSBTs along the IBSI elements in their pre-college (PC), college (C), and field study (FS)

NO.	ITEMS	PC	C	FS	Mean	Int.
Lesson planning and implementation						
4	Limit the use of lecture and direct instruction to occasions where the lesson cannot be taught through hands-on or inquiry-based instruction.	3.45	3.63	3.77	3.62	S
5	Demonstrate flexibility by balancing and mediating their preplanned lessons and questions with the activities and directions prompted by student questions.	3.67	4.09	4.08	3.95	S
6	Assess students' prior knowledge at the start of the lesson and adjust teaching accordingly.	3.74	3.91	4.11	3.92	S

7	Make learning relevant and meaningful by taking students' interests into account and basing lessons on students' prior suppositions.	3.73	4.09	4.02	3.95	S
8	Use counterintuitive demonstrations and discrepant events to pose contradictions and challenge students' previously held beliefs.	3.44	3.74	3.68	3.62	S
12	Arrange students' desks for collaborative work in small groups.	3.80	3.86	3.91	3.86	S
13	Move about the classroom and rotate among small groups throughout the lesson.	3.76	3.74	3.74	3.75	S
21	Assess student performance in a variety of forms.	3.83	4.03	4.09	3.99	S
22	Initiate and orchestrate discourse and scientific argumentation.	3.41	3.75	3.55	3.57	S
	SUB-SCALE MEAN	**3.65**	**3.87**	**3.87**	**3.80**	**S**
	SD	0.80	0.62	0.67	0.61	
	Interpretation	**S**	**S**	**S**		
Content Knowledge						
2	Provide opportunities for metacognitive processes.	3.68	4.08	3.88	3.90	S
9	Use inquiries and investigations to "anchor" new information to previously held knowledge.	3.53	4.03	3.80	3.84	S
14	Encourage students to design and carry out their investigations.	3.44	4.05	3.72	3.73	S
16	Integrate science content with process skills and problem-solving strategies, as well as technology, environment, etc.	3.64	4.20	3.92	3.92	S
17	Act as facilitator, mediator, initiator, and coach while modeling behaviors of inquiry, curiosity, and wonder.	3.98	4.38	4.21	4.21	S
18	Use primary sources of information (journal articles, etc.) rather than, or in conjunction with prescribed textbooks.	3.64	4.25	3.94	3.95	S
20	Encourage students to use concept maps, graphic organizers, and drawings of models to explain and demonstrate newly acquired knowledge.	3.94	4.35	4.10	4.09	S
24	Students showed an interest in science by acting as researchers/investigators.	3.68	4.18	3.85	3.88	S
25	Students are engaged in diligent investigations from their self-generated questions.	3.55	3.88	3.64	3.68	S
26	Students reflected on and took responsibility for my/their learning.	3.86	4.28	4.10	4.13	S
29	Students considered skepticism and alternative models or points of view.	3.82	4.11	4.00	3.99	S
30	Students used claims and unbiased evidence to form explanations and arguments.	3.92	4.25	4.14	4.15	S
	SUB-SCALE MEAN	**3.72**	**4.17**	**3.94**	**3.94**	**S**
	SD	0.84	0.58	0.76	0.65	
	Interpretation	**S**	**S**	**S**		
	Classroom culture					
1	Create a classroom culture that encourages positive scientific attitudes and habits of mind.	3.79	4.11	4.02	3.97	S

3	Stimulate and nurture students' curiosity.	3.83	4.11	3.94	3.96	S
10	Model inquisitive actions by posing prompting and probing questions as well as asking questions that require higher-level and critical thinking skills.	3.59	4.21	4.08	3.97	S
11	Refrain from divulging the answers and pose prompts to clarify students' questions.	3.58	4.02	3.86	3.82	S
15	Keep students on-task by having them support and debate their data, evidence, and conclusion.	3.35	3.97	3.65	3.66	S
19	Encourage communication skills such as speaking and listening.	4.00	4.34	4.26	4.21	S
23	Students enjoyed posing questions and demonstrating a desire to learn.	3.79	4.00	3.94	3.91	S
27	Persisted in asking questions to clarify and confirm the accuracy of their understanding.	4.00	4.11	4.15	4.09	S
28	Students worked respectfully and communicated in collaborative groups.	4.11	4.42	4.18	4.24	S
	SUB-SCALE MEAN	**3.78**	**4.14**	**4.00**	**3.97**	**S**
	SD	0.76	0.57	0.66	0.58	
	Interpretation	**S**	**S**	**S**		
	OVERALL MEAN	**3.69b**	**4.2a**	**4.1a b**	**4.08**	S
	DI	**S**	**S**	**S**	**S**	
	SD	**1.07**	**1.01**	**1.00**	**0.84**	

Subscale means (mean column) with the same letter are not significant at p = .05, Tukey HSD, Means of the same letter are not significantly different at p = 0.05

SCALE	RANGE	FREQUENCY OF OCCURRENCE	INTERPRETATION
1	1.00-1.49	1% - 20%	Very Limited (VL)
2	1.50-2.49	21% - 40%	Insufficient (InS)
3	2.50-3.49	41% - 60%	Moderate (M)
4	3.50-4.49	61% - 80%	Sufficient (S)
5	4.50-5.00	81% - 100%	Extensive (E)

The above result contradicts what seems to be the trend internationally. According to the literature on science reform practices, the adoption of inquiry instruction into the K-12 classrooms remains somewhat elusive, despite inquiry instruction being a prominent feature of national science standards for the past 15 years (Binns & Popp, 2014; Smith, Desimone, Zednerm, Dunn, Bhatt & Rumyantseva, 2007). Moreover, according to Smolleck and Mongan (2011), and

Ramnarain and Hlatswayo (2018), the implementation of such a pedagogical practice continues to be a challenge for many teachers.

The PSBT respondents' sufficient exposure to IBSI likewise contradicts Anderson (2007), Crawford (2000), Friesen and Jardine (2010), Melville, et al., (2008), and Windschitl (2004) who all reported on the limited experience prospective science teachers have on IBSI both in their basic education and teacher-preparation years. This limited exposure to IBSI has also limited the implementation of IBSI by these teachers in their science teaching.

The stark contrast between the result of the study and that of international trend could be due to the differences in the manner of measuring the prevalence of IBSI practices in science teaching and learning. While this study used a questionnaire soliciting the participants' self-assessment of their experiences, other studies could have used more direct procedures such as actual classroom observations triangulated with lesson plan/syllabus and/or the analysis of laboratory manuals (National Research Council, 2006).

The PSBTs' assessment of the levels of their overall IBSI exposure in the three stages (pre-college, college, and field study) was all in the level of "sufficient." However, analysis of variance (ANOVA) indicates the perceived overall exposure levels across the three stages differ significantly ($F = 4.487$, $p = 0.012$, 2-tailed).

Of the three IBSI elements, IBSI exposure in college science courses is perceived to be highest, except along lesson planning and implementation. Meanwhile, perceived IBSI exposure is lowest in the PSBTs' pre-college courses.

Table 11. One-way ANOVA and Tukey HSD on the PSBTs' perceived level of IBSI exposure during their pre-college, college science, and field study courses.

Source	Sum of squares	df	Mean square	F statistic	*p*-value
Treatment	4.1531	2	2.0765	4.4877	0.0124
Error	90.2289	195	0.4627		
Total	94.3819	197			

Treatments pairs	Q statistic	p-value	Inference
Pre-college vs. college science courses	4.1891	0.009	** p<0.01
Pre-college vs. Field study courses	2.6438	0.150	Ns
College science vs. Field study courses	1.5454	0.519	Ns

The result on higher overall IBSI exposure in college science courses contradicts the long-standing notion that college professors generally use lectures and expository procedures in their teaching (Meyer, Hong, & Fynewever, as cited in Holloway, 2015). Accordingly, there is very little learner involvement in most college science courses, and experiments are only done in laboratory periods where very little "real" inquiry activities are done (DeHaan, 2005; Jeanpierre, Oberhauser, & Freeman, 2005; Melville et al., 2008). In particular, the result contradicts that of Aulls, Tabatabai, and Shore (2016), who reported on their pre-service teacher respondents identifying their inquiry experiences greatest during high school, followed by university, then elementary.

The discrepancies in the result between the actual data and long-prevailing notion can be explained by the fact that the data could have been gathered using different tools. While this study gathered data by soliciting the students' self-assessments, other studies could have used more direct, first-hand methods such as classroom observation, or document analysis. Likewise, since the definition of inquiry teaching is still nebulous to the education community, and that no standard instrument has been developed to measure inquiry experiences of students, true

inquiry exposure is difficult to gauge. The interpretation of these results should, therefore, consider this constraint.

Meanwhile, when the perceived overall levels of exposure were compared according to the IBSI elements, the greatest perceived exposure happened along classroom culture, followed by content knowledge. However, variance analysis (ANOVA) revealed that the exposures were statistically tied ($F = 1.560$, $p = .213$ 2-tailed). The PSBTs' mean scores in each of these elements all translate to a "sufficient" level of exposure.

Table 12. One-way ANOVA on the PSBTs' overall perceived level of IBSI exposure along lesson planning and implementation (LPI), content Knowledge, and classroom culture

Source	Sum of squares	df	mean square	F statistic	*p*-value
Treatment	1.1635	2	0.5818	1.5598	0.2128
Error	72.7299	195	0.3730		
Total	73.8935	197			

Comparing IBSI exposure in the three stages according to lesson planning and implementation, ANOVA indicates an insignificant difference, despite higher mean scores during college and field study stages. Meanwhile, according to both content knowledge and classroom culture, there were significant differences in exposure mean scores. In both elements, the PSBTs claim that their exposure levels were highest during college, followed by field study, then pre-college.

Further analysis of the results show that overall, the IBSI practices the PSBTs were least exposed to were Item 22 - "*Initiate and orchestrate discourse and scientific argumentation,*" Item 8 – "*Use counterintuitive demonstrations and discrepant events to pose contradictions and challenge students' previously held beliefs.*", Item 4 – "*Limit the use of lecture and direct instruction to occasions where the lesson cannot be taught through hands-on or inquiry-based instruction*" and Item

15 – "*Keep students on-task by having them support and debate their data, evidence, and conclusion.*" All but one of these items pertains to lesson planning and implementation. The other item (Item 15) came from school culture.

Table 13. One-way ANOVA and Tukey HSD on the PSBTs' perceived level of IBSI exposure along the three IBSI elements during their pre-college, college science, and field study courses.

Lesson planning and implementation

Source	Sum of Squares	df	Mean Square	F statistic	*p*-value
Treatment	2.2226	2	1.1113	2.2610	0.1070ns
Error	95.8447	195	0.4915		
Total	98.0673	197			

Content knowledge

Source	Sum of Squares	df	Mean Square	F statistic	*p*-value
Treatment	6.4447	2	3.2224	5.9141	0.0032**
Error	106.2474	195	0.5449		
Total	112.6921	197			

Treatments pairs	Q statistic	*p*-value	Inference
Pre-college vs. college science courses	4.8638	0.0020541	** p<0.01
Pre-college vs. Field study courses	2.4180	0.2043023	Ns
College science vs. Field study courses	2.4458	0.1970091	Ns

Classroom culture

Source	Sum of Squares	df	Mean Square	F statistic	*p*-value
Treatment	4.2196	2	2.1098	4.7227	0.0099**
Error	87.1146	195	0.4467		
Total	91.3343	197			

Treatments pairs	Q statistic	*p*-value	Inference
Pre-college vs. college science courses	4.3022	0.0075014	** p<0.01
Pre-college vs. Field study courses	2.6861	0.1416243	Ns
College science vs. Field study courses	1.6161	0.4904269	Ns

The items the PSBTs were less exposed to relate to the features that characterize scientific inquiry and the 5E model of teaching (Llewellyn, 2012; Petersen, 2000). The other items the PSBTs are least exposed to were: a) (Item 25) *"Students are engaged in diligent investigations from their self-generated questions"*; b) (Item 14*) "Encourage students to design and carry out their investigations"*; and c)

(Item 13) *"(Teacher) Move about the classroom and rotate among small groups throughout the lesson.".*

The levels of IBSI exposure along the above areas were particularly lower during the PSBTs' pre-college years. This low exposure could be explained by the fact that these "hard-core" inquiry practices are too advanced for younger learners. As described by Banchi and Bell (2008) and Buck et al. (2008), inquiry activities are events that advance with the learners' age/maturity or experience. Hence, the incidence of inquiry instruction is expectedly lower during the pre-college stages.

Meanwhile, the IBSI practices the PSBTs were most exposed to include items 28, 17, 19, 20, and 30. These items came from the domain of classroom culture. The specific items with the greatest perceived exposures were: Item 28 - "*Students worked respectfully and communicated in collaborative groups*" and Item 17 – "*Act as a facilitator, mediator, initiator, and coach while modeling behaviors of inquiry, curiosity, and wonder*" Item 19 – "*Encourage communication skills such as speaking and listening,*" Item 20 – "*Encourage students to use concept maps, graphic organizers, and drawings of models to explain and demonstrate newly acquired knowledge*" and "*Item 30 – "Used claims and unbiased evidence to form explanations and arguments.*" Except for item 30, the above inquiry events are general characteristics that define student-centered learning, which is also part of science education reform efforts (Heim & Holt, 2018).

The qualitative data obtained in the semi-structured interview reveal that the PSBTs were indeed least exposed to IBSI during their pre-college years than either their college and field study observation and teaching internship courses. Close to 75% of the respondents claim that they had limited exposure to IBSI in high school. In contrast, 71% claimed that they had sufficient to extensive experience with IBSI

during their college science courses. These findings seem to support the idea that IBSI and other learner-centered strategies are more appropriate and more applicable for older students and those more inclined into science courses (Banchi & Bell, 2008; Buck et al., 2008)

PSBTs' IBSI understanding. Table 14 reveals that, overall, the PSBT respondents have a limited understanding of inquiry-based science instruction. This level of understanding is gauged in the PSBTs' ability to choose from the given options the IBSI practice, which they think will manifest inquiry practices in the given science lesson or situation. Based on their responses, it can be surmised that the majority of these respondents (54.89%) have a limited to very limited understanding of IBSI practices. They can hardly distinguish the teaching strategies and techniques that reflect IBSI from those that manifest direct teaching approaches. This limited understanding is true in all three lesson stages. Meanwhile, 39.39% hold a moderate level of understanding, while only 6.06% hold an adequate understanding of IBSI practices.

Table 14. Level of IBSI understanding by PSBTs according to lesson stages

According to lesson stage	Mean	St.Dev.	Interpretation
Lesson beginning (3,5,9,14,15)	0.564ab	0.523	Moderate
Lesson proper (1,4,8,10, 11,12,13)	0.361b	0.579	Limited
Lesson ending/wrap-up (2,6,7,16)	0.606a	0.539	Moderate
Overall	**0.485**	**0.462**	**Limited**

Means of the same letter are not significant at p = 0.05, Tukey HSD

Mean scores	Interpretation
0.00 or lower	Very Limited
0.01 - 0.50	Limited
0.51 - 1.25	Moderate
1.26 - 1.75	Sufficient
1.76 - 2.00	Extensive

When compared according to the lesson stage, the PSBTs tend to identify IBSI teaching techniques and principles better when these are used at the beginning

and at the end of the lesson than at lesson proper (Table 5). Analysis of Variance and Tukey's HSD (Table 6) indicate that the PSBTs' IBSI understanding at lesson beginning and at lesson ending was significantly higher than their understanding at lesson proper. Overall, the PSBTs have limited understanding of IBSI principles when these principles are used at lesson proper.

Table 15. One-way ANOVA and Tukey HSD on the PSBTs' understanding of IBSI practices at different lesson stages

Source	Sum of Squares	Df	Mean Square	F statistic	*p*-value
Treatment	2.2549	2	1.1274	3.7646	0.0249*
Error	58.3994	195	0.2995		
Total	60.6542	197			

Treatments pairs	Q statistic	p-value	Inference
Lesson beginning vs. Lesson proper	3.0012	0.087952	Ns
Lesson beginning vs. Lesson ending	0.6298	0.889688	Ns
Lesson proper vs. lesson ending	3.6310	0.029462	* p<0.05

The items where the respondents had lowest overall understanding were those on how IBSI is used to teach the following topics: "Sorting animals" (Item 10), Frog dissection (Item 1), "Fossil analysis" (Item 11), and "A teachable moment on hand sanitizers" (Item 12). Meanwhile, most respondents were able to demonstrate a good understanding of IBSI application on Item 15 - "Chlorophyll."

The PSBT respondents' lack of understanding of IBSI was evident in their answers on the item about "Sorting animals." Most of the respondents mistakenly thought of the didactic and direct option (teacher explaining the rules of classification before allowing the students to apply these rules) and active direct (teacher demonstrating the rules of classification using cards) as manifestations of IBSI practices. As for the item regarding "Frog dissection," more respondents also selected the options that did not reflect inquiry practices. They chose the direct and didactic (teacher demonstration) or active direct methods (student dissection following a focus question provided by the teacher) over the open (student

exploratory dissection) and guided inquiry (student exploratory dissection with teacher probing) choices. Meanwhile, in the case of the item on "Fossil analysis," very few of the respondents chose the two options that reflected the 5E teaching model. Instead of them choosing the options where students explore before teacher presentation, the PSBTs opted for the more traditional approach of providing a formal lecture followed by a confirmatory activity that will prove that such a phenomenon or scientific principle is indeed real. Such confirmation activities are considered non-inquiry activities as they simply verify scientific ideas or processes that are previously learned (Banchi & Bell, 2008; Buck et al., 2008).

The PSBT respondents' limited understanding of IBSI is evident in their responses to the question "What do you understand about IBSI?" during the follow-up interview. The PSBTs' responses range from naïve and simplistic to being over-generalized. The two best answers to the above question are given as follows:

> *"IBSI focuses on the involvement of students in finding answers to questions while they construct new information. IBSI helps the students develop their skills and make students scientifically literate."*

> *"IBSI adopts an investigative approach in teaching and learning where students are provided with opportunities to investigate a problem and search for possible solutions."*

However, more IBSI definitions or descriptions indicate naïve or limited understanding. Some of these definitions or descriptions for IBSI include the following:

> *"Using or posing questions throughout the discussion."*
> *"Teacher asking the ideas and opinions of the students."*
> *"An instruction that uses the art of questioning in the classroom."*
> *"Teacher leads a question-and-answer session."*
> *"Assess students with questions that are relevant to the topic."*

Other IBSI descriptions were either too general or were inappropriate. Some of these descriptions are the following:

"IBSI encourages both teachers and students to be more knowledgeable in all areas."

"In IBSI, both the students and the teachers share information, unlike the traditional way that the teacher is the only source of knowledge."

"Examples of IBSI are experiments that have guide questions."

"IBSI involves sharing ideas with the learners and expounding these ideas through an activity or discussion.

"IBSI is an interactive discussion or lecture where a teacher can formulate an idea by gathering the students' ideas about the concepts they have learned."

The PSBTs' inappropriate ideas about IBSI were supported by their answers when they were asked about their best experience with the teaching strategy. While a few answers are acceptable, many responses reflect their limited understanding. Some of the responses that manifest limited understanding include:

"When (as a student teacher) I let the learners have a short reporting as their activity, then they will ask questions, or I will ask them questions regarding the lesson (sic)" "When as a student-teacher I let the learners have a short reporting as their activity. Then, other learners or I asked questions regarding the report."

"(My best experience with IBSI came with) recitations, group activities, and reporting."

"The teacher discussed the lesson, and as the discussion or the lecture is going on, the teacher asks (sic) questions to the students."

The accounts described earlier indicate that the PSBTs tend to equate IBSI with mere teacher questioning, or teacher-led student recitation. Such a result conforms to that of Lee and Shea (2016), who reported on pre-service science teachers view of IBSI as a mere "asking students questions" rather than it being a formal set of pedagogical tools. These descriptions are quite limited, oversimplified, or too generalized. Asking a lot of questions does not necessarily make an inquiry lesson. According to Llewellyn (2013), a question to be considered inquiry-oriented

reported by Gutierez (2015). It is quite apparent that the in-service science teachers are aware only of the "hands-on" component, and not the minds-on nature of IBSI.

It is, however, quite consoling to know that the PSBT respondents in this study were aware of their lack of understanding of the IBSI as a strategy. When they were asked to assess their readiness to teach using IBSI, many were hesitant to score themselves high. These respondents claim that they still "have to learn more of the strategy" and that they are still "confused as to how IBSI is implemented in science classes." Such admission of lack of knowledge is a positive indication that they are willing to learn more about the strategy and hopefully apply IBSI in their future classrooms.

The PSBTs' moderate but apparent lack of confidence in their understanding of IBSI complements the findings of Lilitsis and Piegaro (2010), and Tatar (2012). This level of understanding about IBSI could act as a barrier in the PSBTs' ability to apply IBSI practices during actual teaching (Binns & Popp, 2014; Blanchard, Southerland, & Ganger, 2009). Teachers must first have enough understanding of teaching with inquiry if they are to enact such a pedagogical approach (Chichekian & Shore, 2016).

On the other hand, many of the PSBTs were aware that IBSI is a student-centered, hands-on, and an inductive teaching model. However, these inquiry descriptions are insufficient as, according to Haury (1993), IBSI is more than just hands-on. Physically doing the activity is not the most essential element of science teaching. This especially true when laboratory activities are of the "cookbook" style or confirmatory in nature, i.e., labs that provide the students with the questions to investigate, what materials to use, and how to go about solving the problem (LLewelyn, 2013). According to Haury (1993), IBSI involves lessons or activities that

allow students to pose questions, gather data, reason from evidence, and communicate explanations based on the collected data. In other words, IBSI involves not only "hands-on," but more importantly, "minds-on" activities.

This limited understanding of IBSI can be attributed to the fact that up to this time, there is still much confusion on the real meaning of the word inquiry (Banchi & Bell, 2008). As such, even science and teacher education professors could hold their misconceptions about IBSI. Indeed, inquiry instruction is a complex and dynamic activity (Ward, 2016) that is not very easy to understand. Such a limited understanding of the true nature of IBSI has important implications on the teaching and demonstration of the strategy in the undergraduate science teaching methods course. As future teachers of science, the respondents are expected to enact IBSI practices in their K-12 science classrooms. It is then imperative that the pre-service science teachers must recognize the importance of participating in professional development activities even as early as their teaching-training years. These professional development activities may come in many forms, from training and seminars, demonstration teaching festivals, or even lesson study activities.

PSBTs' attitudes toward IBSI. A scale of zero to two was used to describe the PSBTs' attitudes toward IBSI. Overall, the PSBTs hold a highly positive attitude toward the use of inquiry-based science instruction as a teaching strategy. Their very high overall attitude scores indicate this level of attitude. This result implies that the teaching and learning practices embedded in IBSI are desirable to the respondents.

Such a result is a positive and welcome development for science teaching and learning, as positive attitudes and high levels of motivation toward a particular practice or action propel someone to act or behave toward these practices. As

Lyngdoh and Sungoh (2017) succinctly point, "Attitude is the most important factor that guides motivation and behavior." Therefore, in the context of this study, a positive attitude toward IBSI will contribute toward the successful implementation of IBSI teaching in the classroom. In contrast, an unfavorable attitude will hinder its application.

Table 16. PSBTs' attitudes toward IBSI

Items	MEAN	Inter.
Interest		
1. I would do anything to learn about the inquiry-based instruction (IBSI)	1.86	VH
4. I am not interested in the IBSI approach. *	1.83	VH
8. The IBSI approach is not interesting for me in any way. *	1.85	VH
9. I like reading books about the IBSI approach	1.14	M
14. I would like to research the IBSI approach	1.47	H
Attribute mean	**1.63b**	**H**
St.Dev.	0.36	
Liking		
3. IBSI is my desired teaching approach.	1.35	H
5. I like the IBSI approach.	1.88	VH
7. I do not enjoy performing activities concerning the IBSI approach*.	1.53	VH
11. I like informing others around me about the IBSI approach.	1.39	H
Attribute mean	1.54b	H
St.Dev.	0.47	
Usefulness		
2. IBSI is an approach that deserves much emphasis.	1.74	VH
6. I like using the IBSI approach in my classes	1.62	H
10. I would like to use the IBSI approach in my future teaching.	1.95	VH
12. IBSI is a useful teaching approach	1.80	VH
13. I believe that I can benefit much from the IBSI approach	1.88	VH
Attribute mean	1.80a	**VH**
St.Dev.	0.29	
Overall Mean	**1.66**	H
St.Dev	**0.28**	

**Items are reverse scored.*
Attribute means of the same letter are not significant at p = 0.05, Tukey HSD

Mean score ranges	Total score ranges	Interpretation
0 and below	0 and below	Very low (VL)
0.01 to 0.50	1 – 7	Low (L)
0.51- 1.25	8 – 16	Moderate (M)
1.26 -1.75	17 – 23	High (H)
1.76 – 2.00	24 – 28	Very high (VH)

The attitude subscale on usefulness received the highest mean attitude scores from the PSBTs, falling under the "very high" category. The result suggests that the PSBT respondents do recognize the curricular benefits of the strategy in science teaching. ANOVA and Post hoc (Tukey's HSD) reveal significantly higher attitude scores along this subscale than the subscales of liking and interest. In particular, the highest rating was given to the item, "*I would like to use the IBSI approach in my future teaching.*" Of the 66 respondents, only two indicated that they were not entirely resolved in using IBSI in their future teaching. This finding is an indication of the respondents' willingness and desire to apply IBSI in their future teaching. Such results are encouraging as they indicate the future biology teachers' open-heartedness to embrace the science teaching reforms mandated in science education standards in many countries. Under this subscale, the only item that did not receive a "very high" attitude score was "*I like using the IBSI approach in my classes,*" which was given a "high" rating.

Table 17. One-way ANOVA and Tukey HSD on the PSBTs' IBSI attitudes along liking, interest, and usefulness

Source	Sum of Squares	Df	Mean Square	F statistic	*p*-value
Treatment	2.3330	2	1.1665	7.9773	0.0005
Error	28.5147	195	0.1462		
Total	30.8477	197			

Treatments pairs	Q statistic	*p*-value	Inference
Liking vs. Interest	1.9635	0.349768	Ns
Liking vs. Usefulness	3.6052	0.030927	* p<0.05
Interest vs. Usefulness	5.5687	0.001005	** p<0.01

The attitude subscale on interest was rated by the respondents as the second highest. The mean attitude scores under this subscale fell under "high." Interestingly, the negatively stated item, "The IBSI approach is not interesting for me in any way," received the highest attitude score. Such results suggest that the IBSI approach attracts the majority (98%) of the pre-service biology teacher respondents. It is just hoped that the PSBTs' interest in IBSI will translate into the utilization of this approach in their future classrooms.

The attitude attribute on general liking received the lowest scores from the PSBTs. However, the mean subscale rating still fell under "high," suggesting that the IBSI approaches are likable to the respondents. Under this subscale, the items receiving higher attitude scores from the PSBTs' were those of their natural liking of IBSI and their enjoyment of the activities in IBSI formats.

The PSBTs' positive view of IBSI is consistent with previous research (Binns & Popp, 2014; Eick & Reed, 2002; Lotter, 2004). In these studies, all the pre-service teacher participants indicated to use inquiry instruction in their careers as teachers. While the respondents recognize that it would not be easy to implement inquiry instruction, they were resolved to implement IBSI in the future, never-the-less.

Other studies investigated on in-service teachers' attitudes toward inquiry instruction and conflicting results have emerged. In a large study involving Chinese teachers, Xie and Sharif (2014) found that in-service primary teachers in China hold a moderate level of attitudes toward inquiry-based learning. Moreover, Ramnarain and Hlatswayo (2018) revealed that the African science teachers they sampled hold a positive attitude toward inquiry in the teaching and learning of Physical Sciences. These teachers recognize the benefits of inquiry, such as addressing learner

motivation and supporting learners in the understanding of abstract science concepts.

Other studies investigated pre-service teachers' (Lyngdoh & Sungoh, 2017) and in-service teachers' (Sthapak & Singh, 2017) attitudes toward constructivist teaching. In these studies, the pre-service teachers and in-service teachers hold a different attitude toward constructivist teaching. While the Indian in-service teachers had demonstrated a positive attitude toward constructivism (Sthapak & Singh, 2017), the opposite is held by Iranian pre-service teachers in the study by Lyngdoh and Sungoh, (2017).

PSBTs' learner-centered views (LCV). The PSBTs scored higher in the learner-centered philosophies (Mean = 21.3) than in the teacher-centered pedagogical views (Mean = 17.6). These differences were tested using the t-test for independent samples. A *t* value of 13.3 was obtained, with a $t_{critical}$ value of 2.00 ($p = 0.000$, 2-tailed). These values mean that the difference between the views was significant.

Of the 66 respondents, only one scored higher in the teacher-centered philosophical views. Meanwhile, seven (10.61%) were fairly neutral, while the majority (58, 87.88%) hold a learner-centered philosophy.

The only area under teacher-centered philosophy where the PSBTs scored higher was on behaviorism. The respondents' behaviorism score was significantly higher than their scores for either perennialism or essentialism ($p = 0.000$, 2-tailed).

The PSBT respondents' adherence to the learner-centered educational philosophies is inconsistent with the teaching approach preferences of pre-service teachers in Ethiopia, as reported by Dejene, Bishaw, and Dagnew (2018). In their study, the pre-service teachers have entered their teacher-education program with a

behaviorist orientation, which is not in harmony with the current reform in science education (p. 8).

However, with Filipino pre-service teachers in focus, more students have expressed adherence to the learner-centered philosophies of progressivism, existentialism, and social reconstructionism (Magulod, 2017; Tupas & Pendon, 2016). Such a philosophical orientation of Filipino pre-service teachers is consistent with the result of this study.

Table 18 below shows the PSBTs' mean ratings on the three learner-centered philosophies. The PSBTs' claim that they are most predisposed toward constructivism, then progressivism, and then social reconstructionism.

Table 18. Learner-centered philosophy orientation of PSBTs

Educational philosophy	Mean	St.Dev.
Learner-centered philosophy		
Progressivism	21.48ab	2.37
Social reconstructionism	20.58b	2.46
Constructivism	21.89a	2.31
Total	21.32	1.85

Means of the same letter under each educational philosophy type are not significantly different.

Despite the apparent similarity of the mean scores, there are significant differences among the PSBTs' scores along the learner-centered educational philosophies (p = 0.006, 2-tailed). One-way variance analysis and post-hoc procedures (Tukey's HSD) in Table 10 show the mean differences of the three teacher-centered views. The PSBTs scored higher under progressivism and constructivism over social reconstructionism, although their constructivism and progressivism scores and their progressivism and social reconstructionism scores do not significantly differ.

In the progressivist view, the learners should be active, and they must learn to solve problems by experimenting and reflecting on their experiences. The students'

interests are vital, as is the integration of thinking, feeling, and doing (Cohen, 1999). On the other hand, constructivists focus on processes of learning rather than on learner behavior (Parkay & Stanford, 2007). They concentrate on the mental processes and strategies that students use to learn, and the students are seen as continually involved in making sense out of activities around them (p. 92). Finally, social reconstructionists use critical thinking skills, inquiry, question-asking, and taking of action as teaching strategies (Cohen, 1999). Students learn to handle controversy and recognize multiple perspectives (p.8).

Table 19. One-way ANOVA and Tukey HSD on the PSBTs' learner-centered philosophical views

Learner-centered philosophical views

Source	Sum of Squares	df	Mean Square	F statistic	*p*-value
Treatment	60.0909	2	30.0455	5.3028	0.0057
Error	1,104.8636	195	5.6660		
Total	1,164.9545	197			

Treatments pairs	Q statistic	*p*-value	Inference
Progressivism vs. Social reconstructionism	3.1027	0.075	Ns
Progressivism vs. Constructivism	1.3962	0.580	Ns
Social reconstructionism vs. Constructivism	4.4989	0.005	** p<0.01

The three learner-centered educational philosophies have explicit ties with each other. All three provide opportunities for extensive interaction between teacher and students and among students themselves. Furthermore, all three philosophical views place a premium on bringing the community, if not the whole world, into the classroom (Parkay & Stanford, 2007). All of these characteristics of teaching-learning conditions are consistent with IBSI.

The above result brings a lot of promise to science education in the future, as science education reforms have emphasized on teachers' adoption of learner-centered teaching and learning practices (DepEd, 2012; NRC, 2006).

PSBTs' self-efficacy to teach using IBSI. Using the scale from one (very low) to 10 (very high), the PSBT respondents are highly self-efficacious to teach using the IBSI strategy (Table 20). This high self-efficacy to teach using IBSI was true in the areas of lesson planning and implementation and content knowledge. Meanwhile, the IBSI self-efficacy along classroom culture was even "very high."

Table 20. PSBTs' self-efficacy to employ IBSI in their teaching

IBSI elements	Mean	St. Dev.	DI
Lesson planning and implementation			
1. CAN use strategies and activities that show respect for students' prior knowledge and their preconceptions or misconceptions found within that knowledge.	8.12	1.41	H
2. CAN design strategies and activities that allow students to use their prior knowledge to explain or predict phenomena and then resolve any results or answers that are surprising to them.	7.92	1.41	H
3. CAN provide opportunities for students to explore first before they are provided with formal presentation (lecture or demonstration, etc.).	8.49	1.35	H
4. CAN modify my lesson depending on the ideas or questions originating from students.	7.87	1.48	H
5. CAN modify my lesson based on the results of my formative assessment strategies (checks for understanding, quick questions, etc.).	8.27	1.17	H
6. CAN pose questions or problems that encourage students to seek and value different ways to investigate or solve a problem.	7.80	1.80	H
7. CAN design lessons that engage students as members of a "learning community," intellectual rigor, constructive criticism, and the challenging of ideas are valued.	7.48	1.61	H
17. CAN use a range of assessment strategies that measure the depth of student understanding and the application thereof.	7.75	1.39	H
Subscale Mean	7.96b	1.09	**H**
Content Knowledge			
8. CAN focus on fundamental concepts of the subject. There are always some significant scientific or mathematical ideas at the heart of each lesson.	8.16	1.59	H
9. CAN implement lessons that emphasize the strong inter-relatedness (how similar or different from previous concepts) of scientific thinking.	8.04	1.39	H
10. CAN see quickly what students are trying to say, how it connects with science concepts, and bring up questions, ideas, or examples that help the student clarify their thinking.	7.98	1.39	H
11. CAN help and encourage students to follow general guidelines, laws, or theories to develop a solution (a model). In my future lessons, relationships or patterns are represented in abstract or symbolic ways (graphs or equations).	7.86	1.30	H

12. CAN use many different real-world phenomena as teaching tools to help students understand basic science and math concepts, not just to entertain them or keep their attention.	8.11	1.42	H
13. CAN require students to use a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, lab materials, etc.) to represent phenomena.	8.29	1.61	H
14. CAN allow the students to make predictions and/or hypotheses, and they are encouraged to devise means to test and then validate or reject these predictions/hypotheses.	7.76	1.49	H
15. CAN let students be actively engaged in thought-provoking activities that often involve the critical assessment of procedures. Students actively think about what they are doing and about how they were doing. From here, they are clarified the next steps in their investigation.	7.67	1.30	H
16. CAN require students to be reflective about their learning. Student reflections could start with questions like, "How did I used to think about this?" "What caused me to change my mind?" "What made it difficult for me to understand this?" etc.	7.60	1.59	H
Subscale Mean	7.94b	1.10	**H**
Classroom culture			
18. CAN require students to communicate their ideas to others using a variety of means and media (Making presentations, brainstorming, critiquing, listening, making videos, group work, etc.).	8.41	1.20	H
19. CAN implement a lesson or activity where there is a high proportion of student talk (student discussion), and a significant amount of it occurs between and among students.	8.07	1.24	H
20. CAN require that students always respect what each student has to say. (Students express their ideas and opinions without fear of censure or ridicule).	8.86	1.14	VH
21. CAN lead or direct unanticipated behavior to rich learning opportunities.	7.83	1.18	H
22. CAN act as a resource person, working to support and enhance student investigations and problem-solving.	8.15	1.18	H
23. CAN be called "teacher as a listener" (This metaphor describes a teacher who is often found helping students use what they know to construct further understanding).	8.73	1.16	VH
24. CAN be approachable and encouraging to students. Students can come to me for consultation/clarifications.	9.46	0.93	VH
Subscale Mean	8.50a	0.88	**VH**
Overall Mean	**7.98**	**1.11**	**H**

Subscale means of the same letter are not significant at p = 0.05, Tukey's HSD.

SCALE	MEAN SCORE RANGES	DESCRIPTIVE INTERPRETATION
1 – 2	1.00-2.49	Very low (VL)
3 – 4	2.50-4.49	Low (L)
5 – 6	4.50-6.49	Moderate (M)
7 – 8	6.50-8.49	High (H)
9 – 10	8.50-10.00	Very High (VH)

The high self-efficacy to teach using IBSI signals a bright future for science education, as the PSBTs were very confident that they can perform IBSI practices identified, and they can apply these strategies in their future teaching.

The result of the analysis of variance and Tukey's HSD indicate that the PSBTs were most self-efficacious along the "Classroom Culture" element of IBSI. Meanwhile, their self-efficacies toward "Content Knowledge" and "Lesson Planning and Implementation" do not significantly differ.

Table 21. One-way ANOVA and Tukey HSD on the PSBTs' IBSI self-efficacy along Lesson planning and implementation (LPI), content knowledge (CK), and classroom culture (CC).

Source	Sum of squares	df	Mean square	F statistic	p-value
Treatment	13.3188	2	6.6594	6.3284	0.0022**
Error	205.2000	195	1.0523		
Total	218.5188	197			

Treatments pairs	Q statistic	p-value	Inference
LPI vs. CK	0.1537	0.899994	Ns
LPI vs. CC	4.2783	0.007903	** p<0.01
CK vs. CC	4.4320	0.005626	** p<0.01

It is noteworthy to emphasize on some specific IBSI items where the PSBTs are most self-efficacious. The PSBTs were very confident that they can "*be approachable and encouraging to students as they come for consultations and clarifications*," "*require students to express their ideas without fear of ridicule*," and "*be called "teacher as a listener.*" In contrast, the PSBTs were less confident in "*designing lessons that engage students as members of a learning community*," "*engaging students in thought-provoking activities that involve critical assessment of procedures*," and "*requiring students to be reflective of their learning.*" Also, the PSBT respondents were less confident in enabling students to "*pose questions or problems that encourage students to seek and value different ways to investigate or solve a problem*," "*use a range of assessment strategies that measure the depth of*

student understanding and the application thereof," and "give the students the opportunity to make predictions and/or hypotheses, and they are encouraged to devise means to test and then validate or reject these predictions/hypotheses." Incidentally, most of these items are "hard-core" events that characterize authentic inquiry (Llewellyn, 2013).

The PSBT respondents' high self-efficacy to teach using IBSI was supported by their answers in the follow-up interview. When they were asked if they were ready to teach using IBSI, 26 out of 32 (81.25%) answered in the affirmative, with 90.25% of them rating their readiness from three to five in a one - to - five scale. Such results contradict that of Roth et al., (1998), and Windschitl and Thompson (2006) who noted on their pre-service teacher respondents' non-readiness to incorporate inquiry instruction in their lessons. Such non-readiness happens despite the pre-service teachers taking science methods courses in their undergraduate level. This result means that after a decade of emphasis on IBSI, future science teachers are developing higher confidence to implement practices related to inquiry teaching.

The PSBT respondents' high self-efficacy to teach using IBSI is a bright spot for the future of science teaching and learning. As self-efficacy is seen as a powerful predictor of teacher's behavior and success in the classroom (Velthius, 2014), self-efficacious teachers will tend to set higher goals toward IBSI teaching, are less afraid to fail, and will find new strategies when old ones fail.

Few published studies described the pre-service science teachers' level of self-efficacy to teach using IBSI. One study (Chichekian, 2014) compared the self-efficacy of pre-service elementary and secondary teachers to enact inquiry instruction using the McGill Enactment of Inquiry Questionnaire-Self-Efficacy-

Teacher version (MEIQ-SET). Results revealed that the elementary and secondary pre-service teachers generally held a high sense of self-efficacy in carrying out most of the pedagogical tasks as described in the MEIQ-SET. Such a result is very similar to the findings of this present study.

Another study investigated classroom teachers' self-efficacy to implement the constructivist approach in teaching (Uredi, 2015). The results showed that these teachers' self-efficacy toward constructivist teaching was high (p. 261).

Finally, one qualitative study determined the factors that affect pre-service teachers' self-efficacy to teach using problem-based learning instead of describing the PSTs' level of self-efficacy (Cyprian, 2014). In this study, the factors that were seen to influence the prospective teachers' self-efficacy are course content, the classroom setting, teachers' self-efficacy, and the formation of peer relationships.

PSBTs' predisposition to teach using IBSI. Overall, the PSBT respondents were moderately predisposed to teach using IBSI (Table 22). However, more than half (57.45%) were highly predisposed to teach using this pedagogical approach.

Table 22. PSBT predisposition to teach using IBSI (HPS = 1.00)

IBSI application in each lesson stage	Mean	St.Dev.	DI
Lesson beginning (2,3,6,10)	0.553b	0.242	M
Lesson proper (1,4,5,7, 8, 11,15)	0.734a	0.196	H
Lesson ending (9,12,13,14)	0.564b	0.268	M
Overall	0.640	0.146	M

Means of the same letter are not significantly different t at p = 0.05, Tukey HSD

Mean score range	Total score range	DI*
0.00 – 0.15	0 – 2	Very low (VL)
0.16 – 0.35	3 – 5	Low (L)
0.36 - 0.65	6 -10	Moderate (M)
0.66 – 0.85	11- 13	High (H)
0.86 – 1.00	14 – 15	Very High (VH)

**DI – Descriptive interpretation*

Variance analysis (ANOVA) reveals significant differences in the respondents' predisposition to use IBSI strategies along the three lesson stages – beginning,

proper, and end ($F = 36.14$, $F_{crit} = 3.08$, $p = 0.000$). The respondents were most predisposed to employ IBSI principles during the lesson proper, while they were less-predisposed to employ IBSI practices at lesson beginning and lesson wrap-up. The PSBTs must, therefore, be trained more on how to employ IBSI practices in these stages of the lesson.

Table 23. One-way ANOVA and Tukey HSD on the PSBTs' IBSI predisposition along the three lesson stages

Source	Sum of Squares	Df	Mean Square	F statistic	*p*-value
Treatment	1.3526	2	0.6763	12.0290	0.000**
Error	10.9634	195	0.0562		
Total	12.3160	197			

Treatments pairs	Q statistic	*p*-value	Inference
Lesson beginning vs. Lesson proper	6.1924	0.001	** p<0.01
Lesson beginning vs. Lesson ending	0.3893	0.899	Ns
Lesson proper vs. Lesson ending	5.8031	0.001	** p<0.01

The PSBTs' moderate predisposition to teach using IBSI contradicts their high self-efficacy to teach using the strategy. While they were highly confident that they can employ IBSI practices in the future, their orientation or tendencies to select these practices over other alternatives was moderate. This difference could be explained by the nature of the instrument used to measure the two constructs. While the instrument used to measure self-efficacy was a Likert-type survey involving the respondents' self-assessment, the other tool requires them to analyze the actual teaching scenario. The respondents' answers to a self-assessment instrument and a "cognitive" test will differ.

The particular items where the PSBTs were lowly predisposed toward IBSI were 13 and 6. Item 13 pertains to how a teacher should synthesize a chapter or unit. Many respondents chose the option that is "active," but does not reflect the IBSI practices to wrap a chapter or unit. Item 6, meanwhile, involves a lesson on food chains. Instead of the respondents choosing the option involving student

exploration before a formal presentation, many of the answers were geared toward the opposite, i.e., a formal definition followed by an activity that further explains or demonstrates the principle. Such confirmation activities, as previously noted, are non-inquiry procedures. It appears that the respondents equate IBSI only with "active," "hands-on approaches," without them considering the "minds-on," "inductive," and "discovery" elements of the approach. Such observations could be explained by their limited understanding of the true nature of IBSI, as described in the previous sections.

There are few studies to which this particular result on the pre-service teachers' predisposition to teach using IBSI can be corroborated. The closest related research is the one by Feyzioglu (2015) on pre-service science teachers' pedagogical orientations of science inquiry continuum. Using an instrument called the Pedagogy of Science Inquiry Continuum Test (PoSICT), the researcher instructed the pre-service science teachers to choose which among the different levels of inquiry (confirmation to open inquiry) they will they use to teach the six different inquiry characteristics (problem/question, procedures/design, results analysis, conclusions, alternative conclusions, results communication). The results of the research showed that the pre-service teachers' orientations were at the structured inquiry level. This result, however, indicates that the pre-service teachers were more oriented on a teacher-centered pedagogy, *i.e.*, the characteristics that would require the student to think independently were given to the student by the teacher.

Another study closely related to this present undertaking is a study on science teachers' pedagogical orientations toward direct and inquiry instructional approaches. The study is an investigation by Sahingoz (2017) among Turkish

middle school science teachers. Using the respondents' answers to the Turkish version of the Pedagogy of Science Teaching Test (POSTT), the author found that 37.88% are more inclined to teach using guided inquiry. In comparison, 24.80% are more predisposed to teach using open inquiry. The other respondents are more inclined to follow the active direct (23.66%), and didactic direct (13.66%) pedagogical approaches. Overall, a more significant number of Turkish science teachers who participated in the study are inclined to use inquiry teaching compared to those who will use the direct instruction models.

PSBTs' application of IBSI during teaching internship. In general, the PSBT respondents were able to sufficiently apply the principles of IBSI during their teaching internship experience (Table 24). Both the pre-service teachers' self-assessment (ITSAI) and their cooperating teachers' ratings (RTOP) indicate that the PSBTs have "often" employed the IBSI practices during their student teaching internship. Many of the respondents (87.90%) were able to "sufficiently" apply IBSI principles. Three respondents (4.55%) were able to extensively apply IBSI practices, while only five (7.58%) were able to apply IBSI practices at a "moderate" extent.

Meanwhile, when the RTOP and ITSAI scores were correlated, the result is a "high correlation" ($r = 0.881$). Such computed value indicates that as regards the PSBTs' application of IBSI during teaching internship, there is a high degree of agreement between the ratings of the cooperating teachers and the PSBTs.

The above results indicate that the PSBTs were able to utilize IBSI principles and practices during their teaching internship experiences. Although the PSBTs did not fully maximize the implementation of IBSI practices, it is nevertheless uplifting to know that these PSBTs have started sowing the seeds of inquiry instruction in the consciousness of their learners. It is likewise fantastic to know that despite the many

demands and concerns of student teaching – class control and classroom management, dealing with individual learners, meeting the expectations of mentors, etc., the PSBTs were able to employ the teaching practices expected of them as future science teachers.

Table 24. PSBTs' extent of application of IBSI practices during teaching internship.

IBSI elements	mITSAI	mRTOP	Mean	DI
Lesson planning and implementation (LPI)				
1. Use teaching procedures or activities that show respect for students' prior (previous) knowledge. This prior knowledge could be wrong and needs to be corrected.	2.94	3.14	3.04	S
2. Designing strategies and activities that allow students to use their prior knowledge to explain or predict phenomena.	2.89	3.03	2.96	S
3. Providing opportunities for students to explore first (do an activity) before he/she provides a formal presentation (lecture or demonstration, etc.).	3.03	2.91	2.97	S
4. Modifying lessons depending on the ideas or questions originating from students.	2.82	2.68	2.75	S
5. Modifying lessons based on the results of students' answers to her formative assessments (checks for understanding, quick questions, etc.).	2.89	2.71	2.80	S
6. Asking questions or problems that encourage students to use different ways to investigate or solve a problem.	2.80	2.82	2.81	S
7. Designing lessons that engage students as members of a "learning community," Here, classmates can give constructive criticisms, or challenge the ideas of others.	2.67	2.77	2.72	S
Sub-scale Mean	2.86a	2.87a	2.86a	S
St.Dev.	0.54	0.60	0.44	
Interpretation	**S**	**S**	**S**	
Content Knowledge (CK)				
8. Focusing on fundamental concepts of the subject. There are always some significant scientific or mathematical ideas at the heart of his/her lesson.	2.82	3.08	2.95	S
9. Connecting present lessons with past or future lessons, or relating present lessons with other subjects.	3.27	3.23	3.25	S
10. Seeing quickly what students are trying to say and how these thoughts connect with science concepts.	2.98	2.65	2.82	S
11. Helping and encouraging students to follow general guidelines, laws, or theories to develop a solution or a model.	3.00	3.05	3.02	S
12. Using many different real-world examples as teaching tools to help students understand basic science concepts.	3.18	2.83	3.01	S

13. Requiring students to use a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, etc.) to represent their knowledge/understanding.	2.82	3.11	2.96	S
14. Giving the students the opportunity to make predictions and/or hypotheses, and encourage them to devise means to test and then validate or reject these predictions/hypotheses.	2.42	2.41	2.42	M
15. Engaging students in thought-provoking activities that often involve the critical assessment of what they are doing.	2.58	2.71	2.64	S
16. Requiring students to be reflective about their learning. Student reflections could start with questions like, "What made it difficult for me to understand this?", etc.	2.53	2.58	2.55	S
17. Using a range of assessment strategies that measure the depth of student understanding and the application thereof.	2.86	2.89	2.88	S
Sub-scale Mean	2.85a	2.85a	2.85a	
St.Dev.	0.53	0.63	0.41	
Interpretation	**S**	**S**	**S**	
Classroom culture (CC)				
18. Requiring students to communicate their ideas to others using a variety of means and media (Making presentations, brainstorming, critiquing, listening, making videos, group work, etc.).	3.06	3.17	3.11	S
19. Implementing a lesson or activity where there is a high proportion of student talk (student discussion) and a significant amount of it occurs between and among students.	2.79	2.65	2.72	S
20. Establishing a climate of respect for what each student has to say.	3.21	3.38	3.30	S
21. Being approachable and encouraging to students, both in and out of class.	3.70	3.80	3.75	S
22. Students are guided to construct their understanding.	3.32	3.24	3.28	S
23. Students can come to him/her for clarification.	3.71	3.76	3.73	S
Sub-scale Mean	3.30b	3.33b	3.32b	S
St.Dev.	0.51	0.53	0.35	
Interpretation	S	S	S	
Overall Application Mean	**2.97**	**2.98**	**2.98**	
St.Dev.	**0.46**	**0.54**	**0.36**	
Interpretation	**S**	**S**	**S**	

Scale	Mean range	Score range	Frequency of occurrence	Descriptive Interpretation (DI)
0	0.00-0.49	0-11	Never	Very Limited (VL)
1	0.50-1.49	12-34	Seldom	Insufficient (InS)
2	1.50-2.49	35-57	Sometimes	Moderate (M)
3	2.50-3.49	58-80	Often	Sufficient (S)
4	3.50-4.00	81-92	Very often	Extensive (E)

Comparing the overall level of application of IBSI principles during the three lesson stages, ANOVA indicates a highly significant difference. Moreover, Tukey's HSD revealed that the PSBTs' IBSI applications in the areas of lesson planning and implementation and content knowledge were significantly higher than in classroom culture. Such a trend of result is consistent in both the cooperating teachers' ratings (RTOP) and the PSBTs' self-assessment (ITSAI).

Table 25. One-way ANOVA and Tukey HSD on the PSBTs' IBSI application along Lesson planning and implementation (LPI), content knowledge (CK), and classroom culture (CC).

Overall application

Source	Sum of Squares	Df	Mean Square	F statistic	*p*-value
Treatment	9.2467	2	4.6234	28.5040	.000**
Error	31.6290	195	0.1622		
Total	40.8757	197			
	Treatments pairs		Q statistic	*p*-value	Inference
LPI vs. CK			0.3893	0.899	Ns
LPI vs. CC			6.1924	0.899	** p<0.01
CK vs. CC			5.8031	0.001	** p<0.01

ITSAI (Self-assessment)

Source	Sum of squares	Df	Mean square	F statistic	p-value
Treatment	8.6394	2	4.3197	15.4362	0.000**
Error	54.5691	195	0.2798		
Total	63.2085	197			
	Treatments pairs		Q statistic	*p*-value	Inference
LPI vs. CK			0.2560	0.899994 7	Ns
LPI vs. CC			6.6735	0.001005	** p<0.01
CK vs. CC			6.9294	0.001005	** p<0.01

RTOP (Cooperating teacher assessment)

Source	Sum of Squares	Df	Mean Square	F statistic	*p*-value
Treatment	9.8877	2	4.9438	14.4047	0.000**
Error	66.9259	195	0.3432		
Total	76.8136	197			
	Treatments pairs		Q statistic	*p*-value	Inference
LPI vs. CK			0.1771	0.899994	Ns
LPI vs. CC			6.4834	0.001005	** p<0.01
CK vs. CC			6.6605	0.001005	** p<0.01

The specific IBSI practices that the PSBT respondents manifested best were "*being approachable and encouraging*," "*Students can come to me for clarifications*," and "*My classes were dominated by a climate of respect for what each student has to say.*" These items received the highest scores in both ITSAI and RTOP. Meanwhile, the item least manifested was "*Giving students the opportunity to make predictions and/or hypotheses, and encourage them to devise means to test and then validate or reject these predictions/ hypotheses.*" The other items with relatively lower scores include "*Requiring students to be reflective about their learning*" and "*Engaging students in thought-provoking activities that often involve the critical assessment of what they are doing.*"

The PSBTs' sufficient application of IBSI during teaching internship somewhat contradicts the findings of Binns and Popp (2013). They noted that the pre-service teachers they sampled found it challenging to incorporate inquiry instruction in their lesson. Also, Nungchalem and his colleagues (2016) noted in their case study of three pre-service teachers that there is a limited application of the IBSI practices among these teaching internship teachers. The classroom of one participant, for example, reflected the traditional, teacher-centered classroom set-up, and has dominantly taught using worksheets.

Meanwhile, when the PSBT respondents' lesson plans were analyzed, there appears to be a limited degree of implementation of the IBSI practices. Further scrutiny of the lesson plans revealed some interesting findings. For instance, some PSBTs did not stick to one type of lesson plan, depending on the nature of their lessons. For lessons that require mastery learning, for example, they used the Madeline Hunter lesson plan model. For those lessons requiring skill development, they shifted to the 5E and other related models. However, many of the respondents

have consistently used one lesson plan format, regardless of the competencies they wished to develop in their learners. This flexibility in lesson planning, however, depends on whether or not the cooperating teacher or the college supervisors allow such freedom. Many college supervisors and cooperating teachers still prescribe the lesson plan format, and they do not allow the pre-service teachers to deviate. Such is manifested among the respondents coming from Institutions B and C.

The application of IBSI principles by the PSBTs was also determined by the nature of the lessons they were assigned to execute. For example, a PSBT who was assigned to teach chemistry and physics for the whole duration of the internship has manifested more of the elements of IBSI. Most of her lessons were laboratory-based, although her procedures were not modified for the activity to manifest a higher level of inquiry. She has operated mostly in the level of structured inquiry. Meanwhile, the PSBTs whose lessons were on human body systems, biodiversity, and space science tend to apply the IBSI to a lesser extent.

Another factor that influenced the application of IBSI by PSBTS appears to be the age or educational level of the learners. The PSBTs who have had their teaching internship among senior high school students have manifested a higher level of IBSI application. On the other hand, those who were assigned to teach in the lower grades (Grades 7 and 8) scored low on IBSI manifestation. Such results are consistent with existing literature where the use of inquiry procedures increases and the level of teacher guidance decreases as the learner advances in age and/or educational levels (Banchi & Bell, 2008; Buck, Bretz, & Towns, 2008).

One possible hindrance to the PSBTs' use of IBSI as described in literature is the mismatch between their teaching orientation and that of their mentor teacher, especially if the latter insists on his/her desired methods of delivery. Indeed, some

pre-service teachers hold a positive attitude toward IBSI, but their inability to observe these practices from their mentor teachers have prevented them from implementing this pedagogical approach (Binns & Popp, 2013). In the case of the participants in this study, however, most of them reported that their cooperating teachers did not dictate or insist on their desired strategy. Instead, these pre-service teachers were permitted to use the strategies and techniques they think are appropriate. However, the cooperating teachers sometimes suggest strategies that they know would work best in a particular lesson or situation. These ideas were revealed during the follow-up interview conducted among the participants.

Correlation Among the PSBTs' IBSI Variables.

The PSBTs' IBSI exposure was negatively correlated to their IBSI understanding and predisposition (Table 26) but positively correlated to their IBSI attitude, self-efficacy, and actual application of IBSI during teaching internship. However, their total IBSI exposure correlated significantly with their understanding of IBSI practices as they occur during lesson proper (LPUnd; r = .353). Meanwhile, the PSBTs' IBSI exposure during their field study courses (FSExpo) showed significant correlations with their overall self-efficacy (r = .289) and with their application of IBSI during teaching internship (r =.308). This result bears important implications on how IBSI practices were demonstrated and practiced by the PSBTs' cooperating and demonstration teachers during their field-study and teaching internship courses. Finally, their pre-college and college IBSI exposures correlated significantly with their interest in IBSI (IntAtt; r = -.278), their understanding during lesson beginning (LBUnd; r = .271) and self-efficacy along classroom culture (CCSE; r = -.250).

Table 26. Inter-correlation matrix among the IBSI variables

	1	2	3	4	5	6
1. IBSI exposure						
2. IBSI Understanding	-.115					
3. IBSI Attitude	.061	.137				
4. Learner-centered views	.002	.341**	.311*			
5. IBSI Self-efficacy	.021	.139	.197	.201		
6. IBSI Predisposition	-.103	.309*	.095	.147	.150	
7. IBSI Application	.017	.198	.299*	.389**	.435**	.130

**Significant at p = 0.05, **Significant at p = 0.01*

The PSBT's IBSI understanding was found to be significantly and positively correlated with their learner-centered views (r = .341) and with their overall IBSI predisposition (r = .309). Also, their understanding of the IBSI principles when employed during lesson proper (LPUnd) were significantly and positively correlated with their IBSI self-efficacy along lesson planning and implementation (r = .246).

The PSBTs' overall IBSI attitude scores (r =.239), and their application of IBSI during teaching internship were positively and significantly correlated. Moreover, there was a positive and significant correlation between the PSBT's interest toward IBSI (IntAtt) and their predisposition to use the IBSI principles at lesson proper (LPPred, r = .256). The same positive and significant correlation was computed between the PSBT's interest toward IBSI (IntAtt) and their self-assessed IBSI application (PTApp; r = .273). There was a positive and significant correlation between their IBSI attitude scores and their learner-centered (r = .311) views.

The significant positive correlation between IBSI attitude and IBSI implementation during internship echoes the result of Xie & Tariff (2014) on the relationship between IBSI attitude and IBSI implementation among Chinese science teachers.

Meanwhile, the PSBTs with learner-centered views tend to apply IBSI practices during teaching internship better, as the two IBSI variables were positively and significantly correlated. Such a result is expected since IBSI is a learner-centered pedagogical approach (Bybee, 2006; Kim, 2001; Prawat, 1997).

Finally, the PSBTs' self-efficacy to teach using IBSI correlated positively and significantly with their application of this teaching approach during their teaching internship. Such a result implies that teachers' pedagogical practices are influenced by their beliefs in their abilities to implement such practices. Moreover, the above significant association between self-efficacy and application was consistent in the result of the two instruments that measure IBSI application, the ITSAI ($r = .367$), and the RTOP ($r = .267$).

The data gathered from this investigation showed that the PSBTs' previous IBSI experiences did not influence their understanding of IBSI as a strategy. Such non-influence means that the PSBTs with higher IBSI exposure did not develop a more sophisticated understanding of the strategy than those with a lower extent of exposure. Such a result seems to contradict the findings from literature, which states that student-teachers' learning histories might especially correlate with the quality of their inquiry understanding (Aulls et al., 2016). Specifically, the two experiences that correlated with higher IBSI understanding are taking a research methods course and completing a thesis (Meijer, 2007) or a major/honors project (Pruitt, 2013). Completing a thesis or project, however, became effective only if the student is guided by a competent mentor (Crawford, 2007).

Predictors of the PSBTs' IBSI Variables

Several simple regression procedures were employed to determine which among the hypothesized IBSI variables could significantly predict the PSBTs' IBSI

understanding, attitude, self-efficacy, predisposition, and application during teaching internship.

Predictors of IBSI understanding. The simple linear regression procedures revealed that the overall and component exposures to IBSI did not predict the PSBTs' IBSI understanding. Similarly, none of PSBTs' exposures to the various IBSI elements emerged as significant predictors of their PSBTs' understanding. This finding seems to draw support from the earlier result on the non-significant negative correlation among their respondents' IBSI exposure and understanding.

Predictors of IBSI attitude. None of the PSBTs' overall and component IBSI exposures were linearly associated with their IBSI attitudes. The IBSI attitude appeared to be independent of IBSI exposure. The result suggests that the respondents who had more experiences with IBSI were not able to develop a more positive attitude toward the teaching approach. The same can be said about their IBSI attitude and IBSI understanding. A greater understanding of IBSI does not necessarily translate into a more positive IBSI attitude.

Concerning learner-centered views, only the PSBTs' scores along progressivism emerged as a significant predictor of IBSI attitudes (Table 27). The PSBTs' overall learner-centered views, and the two other learner-centered views, did not come out as significant predictors. Such a case was despite the earlier result on the significant correlation between overall learner-centered views and IBSI attitude, and of IBSI being a learner-centered pedagogy.

The regression model for the progressivist view predicting IBSI attitude is significant ($p = 0.001$), and it means that every unit increase in the PSBTs' progressivism score corresponds to a 0.668 proportionate increase in their IBSI attitude scores.

Table 27. Linear regression analysis on the relationship among the PSBTs' IBSI variables

a. The PSBTs' IBSI attitudes in relation to their learner-centered views				
Learner-centered views	β	r^2	F	Regression equation
Progressivism	.410	.168	12.936**	8.961 + 0.668 (Prog)

b. The PSBTs' IBSI self-efficacy in relation to their IBSI exposure				
IBSI Exposure	β	r^2	F	Regression model
IBSI exposure at field study (FSExpo)	.289	.083	5.821*	6.491 +0.014 (FSExpo)

c. The PSBTs' IBSI predisposition in relation to their IBSI understanding				
IBSI Understanding	β	r^2	F	Regression model
IBSI Understanding at lesson proper (LPUnd)	.418	.174	13.518**	9.035 + 0.226 (LPUnd)

d. The PSBTs' IBSI predisposition in relation to their IBSI self-efficacy				
IBSI self-efficacy	β	r^2	F	Regression model
IBSI self-efficacy along classroom culture (CCSE)	.371	.138	10.224**	10.384 - 0.080 (CCSE)

e. The PSBTs' IBSI application in relation to their IBSI exposure				
IBSI Exposure	β	r^2	F	Regression model
IBSI exposure at field study (FSExpo)	.308	.095	6.688**	56.610 +0.124 (FSExpo)

f. The PSBTs' IBSI application in relation to their IBSI understanding				
IBSI Understanding	β	r^2	F	Regression model
IBSI Understanding at lesson proper (LPUnd)	.312	.097	6.879**	66.832 + 0.638 (LPUnd)

g. The PSBTs' IBSI application in relation to their IBSI attitude				
IBSI attitude	B	r^2	F	Regression model
Overall IBSI attitude (OvAtti)	.299	.089	6.286*	53.440 + 0.644 (OvAtti)

h. The PSBTs' IBSI application in relation to their learner-centered views				
Learner-centered views	B	r^2	F	Regression model
Progressivism	.410	.168	12.952**	37.548 + 1.438 (Prog)

i. The PSBTs' IBSI application in relation to their IBSI self-efficacy				
IBSI self-efficacy	B	r^2	F	Regression model
Overall IBSI self-efficacy (OvSE)	.435	.189	14.941**	38.081 + 3.745 (OvSE)

The emergence of the progressivist view as a significant predictor of IBSI attitude is in place as the practices in IBSI are consistent with the philosophy of progressivism (Sadker & Sadker, 2003). According to some experts, it is from the

philosophy of progressivism where constructivism (which gave rise to IBSI) arose (Bybee, 2006; Kim, 2001; Prawat, 1997; Sadker & Sadker, 2003). As such, it is quite logical that one's belief in progressivism can easily translate to a more positive attitude toward IBSI.

It is quite surprising to know that while the instrument developer of the Educational Philosophy Self-Assessment Inventory (Cohen, 1999) explains that social reconstructionist philosophy uses critical thinking and inquiry skills, scores in such educational philosophy did not predict IBSI attitude scores. Also, it is equally puzzling to know that the PSBTs' scores along constructivism, which is believed to be the basis of IBSI (Bybee, 2006; Llewellyn, 2002), did not come out as a significant predictor of IBSI attitudes.

The inability of the level of constructivist and social reconstructionist beliefs to predict IBSI attitude scores can be attributed to several factors. One of these factors could be the limited number of the sample involved in the study. Had there been more respondents, the trend could have been different. The second factor could be the difference in the nature or composition of the instruments used to measure the three constructs. While the IBSI attitude scale used statements that directly ask the participants' interest or preference to this approach, the educational philosophy self-assessment instrument that measured constructivist and social reconstructionist beliefs involved questions that dealt with the PSBTs' overall beliefs about schools, and of teaching and learning as a whole. It seems logical to believe that IBSI has some unique elements that are too specific to be captured by a five-item scale of constructivism and social reconstructionism.

Predictors of IBSI self-efficacy. The hypothesized predictors for IBSI self-efficacy were total and component IBSI exposure, IBSI understanding, IBSI attitude,

and learner-centered views. When these supposed predictors were used singly as predictors using the simple linear regression, only IBSI exposure at field study (FSExpo) came out as a significant predictor ($\beta = .289$, $r^2 = .083$). The linear regression model is

IBSI self-efficacy = 6.491 + .014 (IBSI Exposure at field study).

The above equation means that for every unit increase in the PSBTs' IBSI exposure at field study, a corresponding 0.014 increase occurs proportionately in their IBSI self-efficacy.

The above result on the FS exposure significantly predicting IBSI self-efficacy offers some important implications on how IBSI is demonstrated at field study. The role, therefore, of demonstration teachers and cooperating teachers is critical in developing the PSBTs' self-efficacy to implement IBSI. Their demonstration of IBSI practices is crucial for pre-service teachers to acquire higher self-efficacy to implement reform-based teaching strategies.

It is quite surprising to note that none of the PSBTs' overall and component IBSI attitude scores predicted their self-efficacy, despite the apparent similarity in the constructs. However, the results suggest that a positive attitude toward a pedagogical approach does not mean an increased self-efficacy to teach using such an approach.

Predictors of IBSI predisposition. The PSBTs' predisposition to implement IBSI practices is not predicted by their IBSI exposure, attitude, and learner-centered views. However, their IBSI understanding at lesson proper (LPUnd; $\beta = .418$, $r^2 = .174$) and their IBSI self-efficacy along classroom culture (CCSE; $\beta = .371$, $r^2 = .138$) arose as significant predictors.

The ability of IBSI understanding at lesson proper (LPUnd) to predict the PSBT IBSI predisposition can be explained by the similarity in the instruments used to measure understanding and predisposition. The instruments used to measure these constructs were considered "cognitive" tests as the PSBTs were asked to analyze teaching scenarios. Hence, their responses could have been affected by their ability to comprehend the situations. The instruments used for the other IBSI constructs were basically of the "inventory" types that solicited the respondents' and their cooperating teachers' self-assessments. The interpretation of these results must, therefore, be made in light of these constraints.

While self-efficacy can easily be considered as related to predisposition, only the PSBTs' IBSI self-efficacy along classroom culture emerged as a predictor of their IBSI predisposition. Such results can be attributed once more to the difference in the instruments used to measure the two constructs.

Predictors of IBSI application during teaching internship. Of the PSBTs' IBSI exposure, only their exposure during field study emerged as a significant predictor of their IBSI application during teaching internship. Their IBSI exposure during their high school and college science courses were insignificant predictors. As for IBSI exposure at field study (FSExpo), the standard coefficient (β) was 0.308, and the coefficient of determination (r^2) was 0.905. Finally, the regression model was IBSI application = 56.610 + 0.124 (FSExpo). From this equation, one can predict a 0.124-point increase in their IBSI self-efficacy for every unit increase in their IBSI exposure at field study (FSExpo) scores.

The ability of FSExpo to predict IBSI application is similar to its ability to predict IBSI self-efficacy. Once again, it is worth highlighting the importance of how IBSI is manifested by demonstration and cooperating teachers during pre-service

teachers' classroom observations. As the results suggest, the PSBTs who were better exposed to IBSI practices were able to implement these practices in their classrooms. The assignment of PSBTs to cooperating teachers based on the latter's use of IBSI principles is indeed crucial.

Meanwhile, of the PSBTs' IBSI understanding, their understanding at lesson proper came out as the lone predictor (Table 27f). The standard coefficient, coefficient of determination, and regression equation were $\beta = .312$, $r^2 = .097$, and IBSI application = 66.832 + 0.638 (LPUnd). The association was significant at $p = 0.01$ level.

It is notable that while the use of a novel teaching approach may depend partly on how one understands its manner of implementation, the current findings showed that only the understanding of its implementation at lesson proper emerged as the predictor. These results may indicate the need for science education professors to emphasize on how IBSI practices are demonstrated at lesson beginning and lesson ending.

When the association among overall and component IBSI attitudes and IBSI application during teaching internship was explored using stepwise linear regression, the PSBTs' overall IBSI attitude (OvAtti) came out as a significant predictor (Table 27g). The β value was .299 and the $r^2 = 0.089$. The result can be interpreted as the PSBTs' IBSI overall attitude contributes to 8.90% of the variance in their IBSI application at teaching internship. The regression equation was IBSI application = 53.440 + 0.6444 (OvAtti). For every unit increase in the PSBTs' overall IBSI attitude scores, there is a corresponding 0.644 increase in their IBSI application during teaching internship.

The ability of the PSBTs' IBSI attitude to predict their IBSI application during teaching internship was similar to the result among Chinese in-service science teachers by Xie & Tariff. (2014). The authors' findings were also consistent with previous reports on in-service teachers' positive attitudes toward inquiry teaching having important associations with their inquiry practice (Molen & Aldheren-Smeets, 2013; Sumrall, 2008; Thomas, 2008; Tenaw, 2014). Indeed, as Chen and Roegno (2000) contend, "teachers' attitudes affect their degree of commitment to their duties, the way they taught and treated their students, and how they perceive their professional growth." If teachers have positive attitudes toward inquiry teaching, then it might be possible that these positive attitudes can be linked to their behaviors in classroom practice (Xie & Shariff., 2014).

In contrast, the above association between IBSI attitude and IBSI application during internship contradicts the findings of Ramnarain and Hlatswayo (2018). These authors reported on physical science teachers' lesser tendencies to enact inquiry teaching in their lessons, despite their positive attitudes toward the teaching approach. The teacher participants in this study claimed that the implementation of inquiry-based learning is fraught with difficulties, such as availability of laboratory facilities, teaching materials, time to complete the curriculum, and large classes, which creates tension in their willingness to implement it (p. 6).

The PSBTs' overall and specific learner-centered views were also associated with their ability to apply IBSI practices during teaching internship. Of these learner-centered views, the PSBTs' scores along progressivism came out as a predictor of their IBSI practice during their teaching internship (Table 27h). The β value was 0.410, and the R^2 value was 0.168. These obtained values indicate that 16.8% of the variance in the respondents' IBSI application can be attributed to their

progressivist views. Notably, the PSBTs progressivist views also emerged as the sole predictor of their IBSI attitudes. In such attitudes translated positively to their ability to manifest IBSI practices in their internship. Such results could have some implications on the screening procedure for prospective science teachers in teacher-training institutions. In the selection of prospective science majors, it might be beneficial to consider the applicants' level of progressivist beliefs about teaching and learning, as the beliefs in this philosophy can positively predict their utilization of IBSI in the future.

Literature is replete with a positive relationship among what teachers believe in and what they practice. Indeed, these teachers' beliefs about teaching and learning are the major influences in their decisions and choices of pedagogical strategies (Harwood, Hansen & Lotter, 2006; Sikko, Lyngved, & Pepin, 2012). The seminal work of Pajares (1992) succinctly puts this in perspective when he said that the belief teachers hold influence their perceptions and judgments, which, in turn, affect their behavior in the classroom, or that understanding the belief structures of teachers and teacher candidates is essential in improving their professional preparation and teaching practices." Therefore, teachers who are inclined toward student-centered, constructivist, and inquiry-oriented teaching tend to teach using these pedagogical approaches.

The last variable that emerged as a predictor of IBSI use during teaching internship was the PSBTs' overall IBSI self-efficacy ($\beta = 0.435$, $r^2 = 0.189$.). Their overall self-efficacy contributes 18.90% of the variance in their' IBSI use. The linear regression equation was IBSI application = 38.081 + 3.745 (OvSE), which indicates a 3.745 increase in the PSBTs' IBSI use for every unit increase in their overall self-efficacy.

Of the five significant predictors of IBSI application during teaching internship, the PSBTs' IBSI self-efficacy had the highest r^2, followed by their progressivism score. These two variables contribute 18.9% and 16.8% of the variance in the PSBTs' IBSI application, respectively.

The ability of IBSI self-efficacy to predict IBSI implementation can be explained by the definition of self-efficacy, as defined by its proponent, Bandura and his colleagues (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). According to these proponents, self-efficacy "affects the way people think, feel, and motivate. As a result of these effects, self-efficacy is determinative of the levels of endeavoring and being persistent of a student under conditions. The high levels of the feeling of success, self-reliance, and the skills of motivating increase the success, but the low levels of those features decrease the success." Applying these in the context of this study, the greater the self-efficacy towards IBSI, the higher is the tendency to enact IBSI practices.

Many studies support the result on the ability of teachers' IBSI self-efficacy to predict IBSI use during teaching internship. For instance, Leonard, Barnes-Johnson, Dantley, and Kimber (2011) and Smolleck and Mongan (2011) contended that self-efficacy is correlated with teachers' belief about willingness to improve their methods of instruction using inquiry. This result likewise strengthens the contention that teachers with higher self-efficacy for inquiry-based teaching are more likely to be aware of various instructional approaches and were "more open and willing to experiment with innovative approaches that promote autonomous learning" (Ross, Bradley, Cousins, & Gladalla, 1996). Moreover, the result somewhat finds support from Uredi (2015), who reported on science teachers' self-efficacy related to

implementing the constructivist approach, positively predicting their level of creating a constructivist learning environment.

Reconceptualized Framework

In the original framework, the PSBTs' IBSI exposure was hypothesized to influence all other IBSI variables (IBSI understanding, attitudes, self-efficacy, predisposition, and application). In turn, IBSI understanding and learner-centered views were assumed to affect the PSBTs' IBSI attitudes, self-efficacy, predisposition, and application. Then IBSI attitude was hypothesized to affect IBSI self-efficacy, predisposition, and application. It was likewise assumed that the PSBTs' IBSI self-efficacy affects their IBSI predisposition and IBSI application and that their IBSI predisposition influences their IBSI application.

In the reconceptualized framework, it can be seen that the PSBTs' overall IBSI exposure did not significantly affect the other IBSI variables. Only IBSI exposure at field study exerted a significant effect on their IBSI self-efficacy and application. Thus, arrows connecting IBSI exposure at field study to IBSI self-efficacy and IBSI application were drawn. No significant effects on the other IBSI variables were noted with either overall IBSI exposure or its components.

Overall, IBSI understanding also did not significantly affect the other IBSI variables. However, the understanding of IBSI practices applied at lesson proper significantly affected the PSBTs' IBSI application and IBSI predisposition. Such relationships are indicated by arrows originating from IBSI understanding at lesson proper leading to IBSI application and IBSI predisposition.

Furthermore, the regression procedures showed that the PSBTs' progressivist views significantly influenced their IBSI attitudes and application, although overall

learner-centered views did not exert the same effect. Neither overall IBSI self-efficacy and predisposition nor their elements were significantly affected by any of the learner-centered views. Arrows were drawn to show these relationships in the reconceptualized framework.

The PSBTs' overall IBSI self-efficacy, meanwhile, significantly affected their IBSI application. However, their IBSI self-efficacy along classroom culture was able to influence their IBSI predisposition significantly. Finally, neither overall IBSI predisposition nor its elements significantly affected the PSBTs' IBSI application.

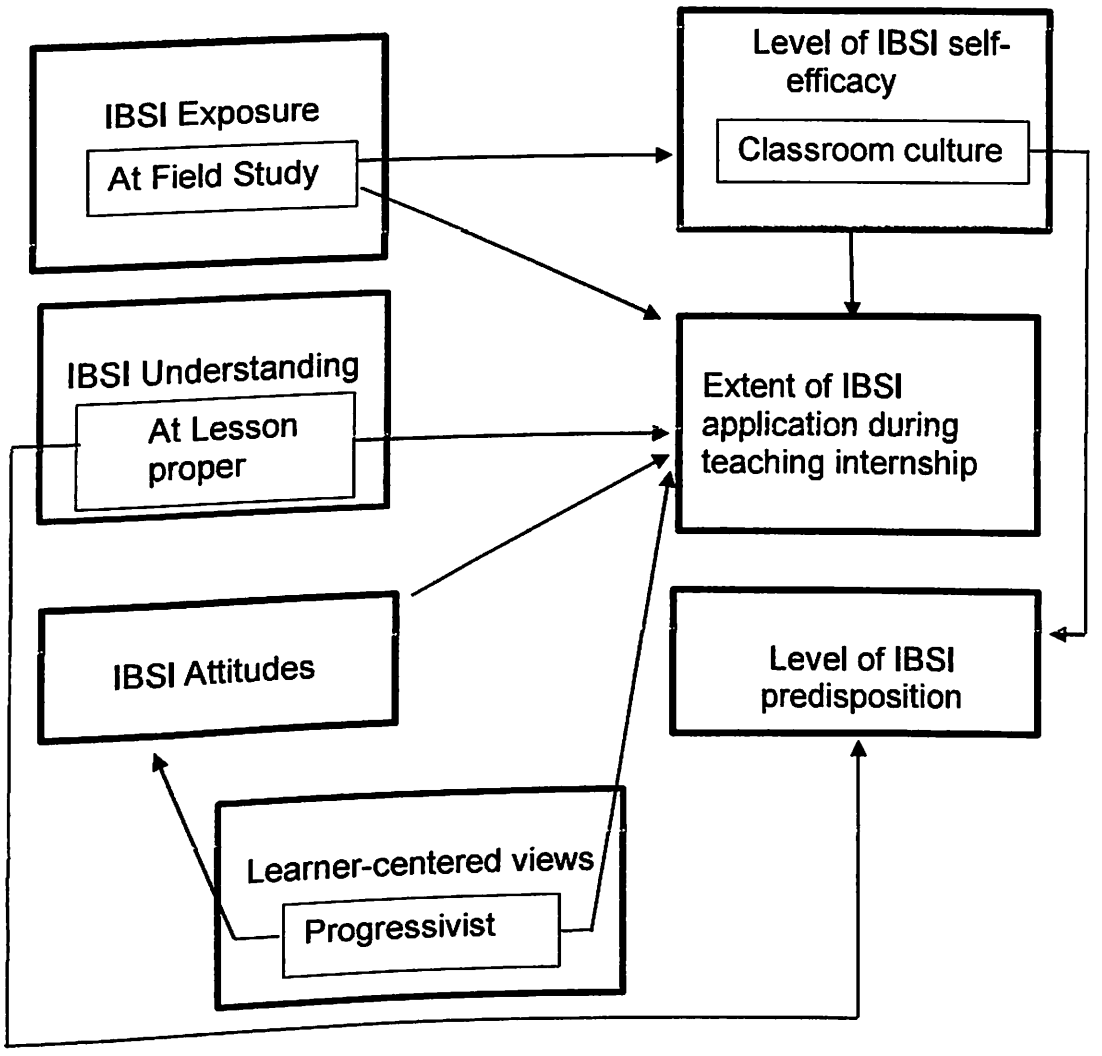


Figure 2. Reconceptualized framework of the study

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of the study, the highlights of findings, as well as the conclusions and the recommendations deduced from the study's findings.

Summary

This study was conducted to determine the factors that influence the pre-service biology teachers' (PSBTs) IBSI understanding, attitudes, self-efficacy, extent of application of IBSI during their teaching internship experience, and their level of IBSI predisposition. Specifically, this study was undertaken to answer the following questions:

1. How do the following variables, taken singly, influence the PSBTs' IBSI self-efficacy?
    a) IBSI exposure
    b) IBSI understanding
    c) IBSI attitudes
    d) learner-centered views
2. How do the following variables, taken singly, influence the PSBTs' extent of application of IBSI during their teaching internship experience?
    a) IBSI exposure
    b) IBSI understanding
    c) IBSI attitudes
    d) learner-centered views
    e) IBSI self-efficacy
    f) IBSI predisposition

3. How do the following variables, taken singly, influence the PSBTs' level of IBSI predisposition?
    a) IBSI exposure
    b) IBSI understanding
    c) IBSI attitudes
    d) learner-centered views
    e) IBSI self-efficacy
4. How does the PSBTs' IBSI exposure influence their IBSI understanding?
5. How do the following variables, taken singly, influence the PSBTs' IBSI attitudes?
    a) IBSI exposure
    b) IBSI understanding
    c) learner-centered views
6. How are the following variables correlated?
    a) IBSI exposure
    b) IBSI understanding
    c) IBSI attitudes
    d) learner-centered views
    e) IBSI self-efficacy
    f) IBSI predisposition
    g) extent of IBSI application during teaching internship

Sixty-six (66) pre-service biology teachers (PSBTs) from three teacher-education institutions in the Baguio City and Benguet were the participants of the study. Survey and interview were the main data-gathering procedures employed. Both quantitative and qualitative data were gathered from the respondents. The

following instruments were used: Science Teachers' Inquiry Practices Scale (STIPS), Pedagogy of Science Testing Test - Biology Items (POSTT-B), the Attitude Scale for IBSI Use (ASIU), Inquiry Use Self-efficacy Scale (IUSES), Test for Inquiry Pedagogy in Science – Biology (TIPS-B), Modified Reformed Teaching Observation Protocol (mRTOP), Modified inquiry Teaching Self-Assessment Instrument (mITSAI), and Educational Philosophies Self-Assessment Instrument (EPSAI). A researcher-made rubric, the Rubric on IBSI Manifestation in Lesson Plans (RIMLP), was also used to support the result on the level of IBSI application during teaching internship. Follow-up interviews were also conducted to supplement the quantitative results gathered from the research instruments.

Descriptive statistics (mean and standard deviation) were used to summarize data, while inferential statistics (Analysis of variance and Tukey HSD) were used to test for significance and to compare means. Pearson correlation and linear regression procedures were employed to describe the relationship among the PSBTs' IBSI variables.

Findings

The summary of the findings of the study is presented vis-à-vis the research questions asked.

1. The overall level of IBSI exposure is moderately high, with a mean of 4.08. This moderately high level of exposure is consistent across stages and the IBSI elements. Their highest IBSI exposure occurred in their college science courses (mean = 4.24), followed by their field study courses (mean = 4.11), and then by their pre-college science courses (mean = 3.69). While IBSI exposures were all "sufficient" across the three stages, there was a statistically significant difference in these exposures ($F = 4.4877$, $p = 0.012$). Pre-college science exposure was

significantly lower than college science exposure, but statistically even with field study exposure. College science exposure did not significantly differ with field study exposure.

Along the three areas of IBSI, the PSBTs' exposure was highest along classroom culture (CC; mean = 3.97), followed by content knowledge (CK; mean = 3.94), and then lesson planning and implementation (LPI; mean = 3.80). However, these differences are statistically insignificant.

Comparing the levels of IBSI exposure in the three stages along LPI, no significant differences were noted (range = 3.65 to 3.87). However, along content knowledge (range = 3.72 to 4.17) and classroom culture (range = 3.78 to 4.14), college science exposures were statistically higher than pre-college science exposures, but statistically tied with field study exposures.

2. Overall, the PSBTs' scored low in the test for IBSI understanding (POST-B) with a mean of 0.485. While their IBSI understanding at lesson beginning (0.564), and at lesson ending was statistically higher (0.606) and falling under moderate understanding, their IBSI understanding at lesson proper pulled them down (mean = 0.361, limited). The level of understanding at the three lesson stages was significantly different ($F = 3.765$; $p = 0.025$).

Further, qualitative results show that many PSBTs' equate IBSI with teacher questioning or teacher-led recitation. They see IBSI as mere teacher-questioning, instead of looking at it as a formal pedagogical model where students make questions, and explore answers to these questions.

3. The PSBTs' have high attitude scores about IBSI (mean = 1.66). They had the highest attitude scores along the usefulness dimension (mean = 1.80, very high), followed by the interest dimension (mean = 1.63, high), and then by liking

dimension (mean = 1.54, high). There was a significant difference in the PSBTs' IBSI attitudes along the three dimensions (F = 9.977, p = 0.001). The difference between liking and interest dimensions was insignificant, unlike the difference between liking and usefulness, and interest and usefulness, where there was significant, and highly significant difference, respectively.

4. In terms of learner-centered philosophical views, the PSBTs scored highest under constructivism (mean = 21.89), then progressivism (mean = 21.48), and then social reconstructionism (mean = 20.58). The scores in these three learner-centered views are significantly different (F = 5.303, p = 0.006). The PSBTs' scores under progressivism and constructivism are statistically even, while scores in constructivism, but not progressivism, are statistically higher than their scores in social reconstructionism.

5. The PSBTs' scores under IBSI self-efficacy were fairly high, with a mean of 7.98 out of 10. This high self-efficacy was consistent along lesson planning and implementation (mean = 7.96, high) and content knowledge (mean = 7.9, high). However, the PSBTs' IBSI self-efficacy along classroom culture was very high (mean = 8.50, very high). The PSBTs' levels of self-efficacy are statistically different (F = 6.324, p = 0.0002). The lesson planning and implementation (LPI) and content knowledge (CK) self-efficacies are not different statistically. Still, LPI and classroom culture (CC), and CK and CC self-efficacy differences, are significant.

6. As to the PSBTs' predisposition to teach using the IBSI approach, they scored a mean of 0.640 out of 1.00. While they have high predispositions to use IBSI at lesson proper (0.734), their tendencies to use the strategy at lesson beginning (mean = 0.553), and at lesson ending (mean = 0.564) are in the moderate. The

PSBTs' level of IBSI predisposition was significantly higher at lesson proper than at lesson beginning and lesson ending. The difference in their levels of predisposition before and after the lesson proper was insignificant.

7. The PSBTs scored a mean of 2.98 out of 4 in their ability to apply for IBSI during their teaching internship. Further, the PSBT respondents and their cooperating teachers are consistent in their assessment of the PSBTs' IBSI application. The majority of the PSBTs (87.90%) were able to apply IBSI practices sufficiently, while 4.55% and 7.58 were able extensively and moderately to manifest IBSI practices, respectively.

The IBSI practices were best manifested along classroom culture (mean = 3.32), then along LPI (mean = 2.86) and content knowledge (mean = 2.85). There was a significant difference in the PSBTs' IBSI application along the three elements ($F = 28.504$, $p = 0.000$). Moreover, the IBSI application along classroom culture was significantly higher than either along LPI or along content knowledge. Applications along LPI and content knowledge, meanwhile, are statistically insignificant.

When the PSBTs' lesson plans were analyzed, some trends emerged. For instance, those who taught younger learners tend to have a limited application of IBSI principles. Moreover, those who taught physical science (Chemistry and Physics) had more inquiry-oriented lessons than those who taught Biology or Earth Science lessons.

8. As to the correlation among the IBSI components, overall IBSI exposure was negatively correlated with IBSI understanding ($r = -.115$) and predisposition ($r = -.013$), but positively, albeit weakly correlated with IBSI attitude ($r = .061$), self-efficacy ($r = .021$), application ($r = .017$), and learner-centered views (.002). IBSI

understanding meanwhile, was significantly correlated with learner-centered views (r = .311**) and IBSI predisposition (.309*), but weakly correlated with IBSI attitude (r = .137), self-efficacy (r = .139) and application (.198). Furthermore, IBSI attitude was significantly correlated with learner-centered views (r = .311*) and IBSI application (.299*), and weakly correlated with self-efficacy (r = .197) and predisposition (r = .095). There was significant correlation between learner-centered views and IBSI application (r = .389**), and weak correlation with IBSI predisposition (r = .147) and self-efficacy (.201). IBSI self-efficacy weakly correlated with predisposition (r = .150), but significantly correlated with application (r = .435**). Finally, the IBSI predisposition and application correlation was weak (r = .130).

The results of simple linear regression procedures showed that none of the PSBTs' overall and component IBSI exposures predicted their IBSI understanding. Also, none of their overall and component IBSI exposures and understanding emerged as predictors of their IBSI attitudes. However, their progressivist views predicted their overall IBSI attitudes ($\beta = .410$, $R^2 = .168$). The regression equation was Attitudes = 8.961 + 0.668 (Progressivism score).

Meanwhile, when overall and component IBSI exposures, understanding, attitudes, and learner-centered views were entered as predictors of the PSBTs' IBSI self-efficacy, only their IBSI exposure at field study (FSExpo) came out as a valid predictor. The obtained standardized coefficient β was = .289, and the R^2 was .083. The regression equation was IBSI self-efficacy = 6.491 +0.014 (FSExpo).

As to IBSI predisposition, two valid predictors came out – IBSI understanding at lesson proper (LPUnd), and IBSI self-efficacy along classroom culture (CCSE).

As for the former, $\beta = .418$, $R^2 = .174$ and the regression equation was IBSI predisposition = 9.035 + 0.226 (LPUnd). In terms of CCSE, $\beta = .371$, $R^2 = .138$ and the regression equation was IBSI predisposition = 10.384 - 0.080 (CCSE).

Finally, the IBSI application at teaching internship was predicted by five predictors. These predictors are as follows: FSExpo [$\beta = .308$; $R^2 = .095$; IBSI Application = 56.610 +0.124 (FSExpo)], LPUnd [$\beta = .312$; $R^2 = .097$; IBSI Application = 66.832 +0.638 (LPUnd)], IBSI attitude [$\beta = .299$; $R^2 = .089$; IBSI Application = 53.440 +0.644 (IBSI attitude)], Progressivism [$\beta = .410$; $R^2 = .168$; IBSI Application = 37.548 +1.438 (prog)], and IBSI self-efficacy [$\beta = .435$; $R^2 = .189$; IBSI Application = 38.081 +3.745 (IBSI Self-efficacy)].

Conclusions

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

1. The PSBTs possess a sufficiently firm foundation of IBSI in all of its aspects – lesson planning and implementation, content knowledge, and classroom culture - as they come into teaching internship. This strong IBSI foundation was built particularly during their college science courses and field study experiences. Likewise, their pre-college science courses have somehow introduced them to IBSI practices.
2. The PSBTs still have a lot to learn about IBSI as their knowledge and understanding of the approach was insufficient. Their IBSI definitions are still unacceptable, as these definitions are laden with naïve ideas or misconceptions.
3. The PSBTs hold a positive attitude toward IBSI. They particularly believe that IBSI is a useful, interesting, and likable teaching approach.

4. The PSBTs had high adherence to the learner-centered philosophies. Specifically, they identify themselves more as constructivists and progressivists, rather than as social reconstructionists.

5. The PSBTs are highly self-efficacious in using IBSI in their future science teaching. However, these IBSI self-efficacies differ across the three IBSI elements. The PSBTs hold the greatest self-efficacies along classroom culture.

6. The PSBTs are moderately predisposed to employ IBSI practices in their teaching. Their IBSI predisposition, however, differs along the three lesson stages. IBSI predisposition is particularly high along lesson proper.

7. The IBSI application by the PSBT respondents was sufficient. The cooperating teachers and the PSBT ratings were consistent in terms of the latter's' IBSI application. Moreover, while IBSI practices were sufficiently manifested in all three IBSI elements, the manifestation along classroom culture was the highest.

8. Learner-centered views significantly correlated with the PSBTs' IBSI understanding and attitude, and a linear association between IBSI predisposition and understanding has surfaced. Meanwhile, IBSI attitude, self-efficacy, and learner-centered views significantly correlated with IBSI application at teaching internship. Moreover, the PSBTs' progressivist views significantly predicted their IBSI attitudes, and their IBSI exposure at field study was the only predictor of their IBSI self-efficacy. Meanwhile, the PSBTs' IBSI understanding at lesson proper, and their IBSI self-efficacy along classroom culture emerged as the significant predictors of their IBSI predisposition. Finally, their IBSI applications during teaching internship were significantly predicted by their IBSI exposure at field study, IBSI understanding at lesson proper, overall IBSI attitudes,

progressivist views, and overall IBSI self-efficacy. Of these predictors, overall IBSI self-efficacy seems to be the best predictor of IBSI application, followed by the PSBTs' progressivist views.

Recommendations

Based on the findings and conclusions, the following recommendations are put forward:

1. For the science professors to team up with science education professors to further strengthen the inquiry foundations of pre-service science students. This collaboration can be accomplished by providing the maximum inquiry experiences to these science education students. This way, the pre-service science teachers will feel that indeed, IBSI is a default teaching approach, a *sine qua non*, in science education, as described in science education reform documents around the world.
2. Science education professors, those in charge of the teaching of methods to pre-service science teachers, may strive harder to emphasize the true nature of IBSI in their science teaching methods courses. More time should be provided for the understanding of IBSI and its many variations, and the pre-service teachers must be given more opportunities to observe and experience inquiry practices in actual classes. These observations and experiences should be efficiently monitored, and constant feedback must be done to improve the pre-service teachers' understanding of how IBSI is implemented in actual classes. A learning module that focuses only on IBSI may also be provided as supplementary materials for pre-service science teachers.
3. As often as necessary cooperating teachers must strive to employ IBSI practices in their teaching, especially when pre-service teachers are observing

them. When necessary, these cooperating teachers must be retooled on the principles and practices of IBSI through a training-workshop.

4. Aside from science content knowledge, teacher education students who wish to specialize in science may also be screened in terms of their attitudes toward inquiry instruction, their levels of learner-centered views, and their self-efficacy to teach using IBSI. All of these variables emerged as significant predictors of IBSI application during internship.

5. As IBSI exposure at field study emerged as a significant predictor of IBSI application during internship, some mechanisms must be employed to place prospective science teachers under demonstration teachers or mentors who are adept at the use of IBSI in science teaching.

6. Since this study covers only the biological sciences majors, it does not provide a comprehensive account of the IBSI features of those from the physical sciences. It is thus recommended that a similar study be conducted among these cohorts.

7. It might also be worth investigating to determine how those with science teaching scholarships compare with non-scholars as to the various IBSI variables. Also, an investigation on how pre-service science teachers from Centers of Excellence or Centers of Excellence in Teacher Education and those who belong to non-centers of excellence/development compare as to their IBSI competencies is worthwhile.

8. The instruments used in this study can further be polished so that they will effectively measure the constructs they are intended to measure.

9. More direct data-gathering procedures such as lesson plan analysis and/or actual teaching observations are recommended for future researchers who want

to duplicate this study. The purpose of such is to prevent the tendencies of some respondents to overrate themselves during self-assessments. As regards the pre-service teachers IBSI application during teaching internship, the students may also be surveyed or interviewed on their teachers' actions. Science professors and teachers may also be tapped as respondents to determine their IBSI exposure or experiences. Moreover, the syllabi and/or the laboratory manuals of science professors and teachers may also be analyzed as to how these manuals emphasize IBSI.

10. The practice of lesson study must be introduced as early as during teaching training, particularly during the methods of teaching courses of the pre-service teachers. Through lesson studies, pre-service teachers are trained to collaborate with their peers and with other experts and be reflective of their lessons and their teaching practices. Moreover, lesson studies train pre-service teachers to become more critical of a lesson in terms of its being inquiry-oriented and constructivist-based.

11. The following studies are recommended for future research:

    a. Tracking how Filipino in-service teachers implement IBSI practices in the field.

    b. Follow-up on how Filipino pre-service teachers implement IBSI practices during the first three years of teaching.

    c. How experiences or exposure to IBSI affect pre-service and in-service science teachers' basic and integrated science process skills.

    d. How experiences or exposure to IBSI influence pre-service science teachers' level of scientific literacy.

e. Comparison of IBSI exposure and attitude of pre-service science teachers who are taught following either the self-contained scheme or the inter-college/department format.

f. Analysis of science teachers' and professors' attitudes and implementation of IBSI practices in their science classes.

g. Analysis of how science cooperating teachers model inquiry-based instruction and how these practices influence the pre-service teachers' application of such teaching approaches.

IBSI - Use Capability Building for Pre-service Biology Teachers and Cooperating Teachers

As suggested in the study, the PSBTs' understanding of IBSI as a teaching strategy must be developed, as an incomplete grasp of IBSI could undermine their implementation of such a strategy in their future classes. Similarly, the study noted that the PSBTs' IBSI exposure at field study was a significant predictor of their IBSI application during their teaching internship. It is, therefore, necessary to enhance the knowledge, skills, and competencies of both pre-service biology and cooperating teachers on IBSI. A capability building program designed specifically for these two cohorts of science teachers is, therefore, a must.

In the case of the PSBTs, one capability building program that could enhance their IBSI competencies is through curriculum enhancement. In the latest curriculum issuance for science education majors by the Philippine Commission on Higher Education, a three-unit, one-semester course on teaching the specific field (Sci.Ed. 153 – The Teaching of Science) is mandated. It is in this course that IBSI can be integrated into the existing curriculum. The discussion of IBSI can be enhanced in

the course syllabus. The curriculum framework for IBSI integration is shown in Appendix Q.

On the other hand, science cooperating teachers must be invited to participate in an IBSI-use training-workshop. This training-workshop could be sponsored by the teacher-education institution and will be provided for free as part of the partnership program.

Below are the topics that are deemed essential and must be part of the capability building program for both science pre-service and cooperating teachers (CTs).

Topic 1: The national science education standards

Topic 2: Introduction to IBSI

Topic 3: The philosophy of IBSI

Topic 4: The different levels of IBSI

Topic 5: Modifying a laboratory activity into an inquiry-based investigation

Topic 6: Using the lesson study framework in analyzing IBSI lessons

Topic 7: Managing the inquiry classroom

Topic 8. Creating a classroom culture of inquiry

The details for the above topics were presented as a scope and sequence for IBSI integration in Appendix R. As for cooperating teachers, a design for a proposed training-workshop on the use of IBSI is shown in Appendix V.

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Appendix A
Letter to the Dean – Saint Louis University

Faculty of Education
University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

DR. FELINA P. ESPIQUE
Dean – Sch. of Teacher Education and Liberal Arts
Saint Louis University
Baguio City, Philippines

Ma'am:

Greetings!

I am a Ph.D. in Education (Biology) student at the University of the Philippines Open University working on a dissertation on Inquiry-based science instruction and biology teacher preparation. I am being supervised by Professor Maria Helen d. Catalan, Ph.D., who is the Deputy Director for Research and Extension at the University of the Philippines National Institute for Science and Mathematics Education Development.

As you have a relatively larger number of Biological Science majors, I am choosing your institution as one of the sources of the participants for my research.

I am therefore humbly requesting your permission for me to gather relevant data from your graduating Biological Science majors. If approved, please allow me to meet my prospective respondents on **May 15, 2018,** from **3:00 to 5:00 p.m**. Rest assured that I will faithfully abide by your institutional policies on the conduct of data-gathering procedures.

As I look forward to your positive response, I thank you very much!

Respectfully yours,

APLER J. BANSIONG
Ph.D. Ed (Biology) Candidate
University of the Philippines
Open University

Appendix A
Letter to the Dean – University of Baguio

Faculty of Education
University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

DR. BERNADITA AYUNON
Dean – Sch. of Teacher Education
University of Baguio
Baguio City, Philippines

Ma'am:

Greetings!

I am a Ph.D. in Education (Biology) student at the University of the Philippines Open University working on a dissertation on Inquiry-based science instruction and biology teacher preparation. I am supervised by Professor Maria Helen d. Catalan, Ph.D., who is the Deputy Director for Research and Extension at the University of the Philippines National Institute for Science and Mathematics Education Development.

As you still cater to Biological Science majors, I am choosing your institution as one of the sources of the participants for my research.

I am therefore humbly requesting your permission for me to gather relevant data from your graduating Biological Science majors. If approved, please allow me to meet my prospective respondents on **May 17, 2018,** from **3:00 to 5:00 p.m**. Rest assured that I will faithfully abide by your institutional policies on the conduct of data-gathering procedures.

As I look forward to your positive response, I thank you very much!

Respectfully yours,

APLER J. BANSIONG
Ph.D. Ed (Biology) Candidate
University of the Philippines
Open University

Appendix A
Letter to the Dean – Benguet State University

Faculty of Education
University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

DR. IMELDA G. PARCASIO
Dean – College of Teacher Education
Benguet State University
La Trinidad, Benguet, Philippines

Ma'am:

Greetings!

This is to request your permission for me to gather data from our Biological Science majors. I am working on Inquiry-based science instruction and biology teacher preparation. I am supervised by Professor Maria Helen d. Catalan, Ph.D., who is the Deputy Director for Research and Extension at the University of the Philippines National Institute for Science and Mathematics Education Development.

If approved, please allow me to meet my prospective respondents on **May 18, 2018,** from **3:00 to 5:00 p.m**. Rest assured that I will faithfully abide by our policies on the conduct of data-gathering procedures.

As I look forward to your positive response, I thank you very much!

Respectfully yours,

APLER J. BANSIONG
Ph.D. Ed (Biology) Candidate
University of the Philippines
Open University

Appendix B
Cover letter to the respondents

Faculty of Education
University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

Dear Pre-service Biology Teacher,

You are being asked to take part in a research study. This study is called "Inquiry-based science instruction and biology teacher preparation: Exposure, Self-efficacy, predisposition, and application." The study is being done by **Apler J. Bansiong**, who is a graduate student at the University of the Philippines Open University. Mr. Bansiong is being supervised by Professor Maria Helen d. Catalan, Ph.D., who is the Deputy Director for Research and Extension at the University of the Philippines National Institute for Science and Mathematics Education Development.

This study will investigate your level of exposure to, understanding of, attitude towards, self-efficacy and predisposition to teach inquiry-based science instruction, and your extent of application of inquiry-based practices during teaching internship. In this study, you will be asked to complete seven questionnaires. Afterward, you will be asked to take part in a brief interview session that will be recorded. It should take no more than 10 minutes to answer the interview questions.

Being a part of this study will not cost anything, and you will not be compensated for being part of this study. (But you will be given a token amount for snacks and meals). No risk is foreseen as no sensitive surveys or interviews will be used. Although you will not benefit personally from being in the study, you may feel good about knowing that you have helped shape future instruction in high school science. The result of this study will hopefully provide important insights on how to prepare biology teachers for future teaching better.

You may choose not to take part in the interview portion of the study. Taking part in this study is voluntary. It is your free choice. You can refuse to be in it at all. If you start the study, you can stop at any time. There will be no effect on your relations with the researcher or the institution he represents. If you have questions, concerns, or complaints about the study right now, please feel free to ask.

Thank you.

Respectfully yours,

APLER J. BANSIONG
Researcher

Appendix C

Letter to the TIPS-B Validators

University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

DR. BENILDA Z. NARCELLES
Faculty
University of Baguio
Baguio City, Philippines

Ma'am:

Greetings!

I am a Ph.D. in Education (Biology) student at the University of the Philippines Open University working on a dissertation on Inquiry-based education and biology teacher preparation. I am being supervised by Dr. Maria Helen D. Catalan of UPNISMED. One of my research questions pertains to the future biology teachers' predisposition to teach using inquiry instruction, and I developed an instrument (Test for Inquiry Pedagogy in Science – Biology, TIPS – B) to measure this construct.

Cognizant of your expertise in research instrument development, I am respectfully requesting you to evaluate the instrument's content validity. You may comment on both the items and the options and provide suggestions to improve the items. I am confident that your comments and suggestions will contribute much to the instruments' strength.

As I look forward to your positive response, I thank you very much!

Respectfully yours,

APLER J. BANSIONG
Ph.D. Ed (Biology) Candidate

Appendix C
Letter to the TIPS-B Validators

University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

DR. EDDIE G. FETALVERO
Professor
Romblon State University
Odiongan, Romblon, Philippines

Sir:

Greetings!

I am a Ph.D. in Education (Biology) student at the University of the Philippines Open University working on a dissertation on Inquiry-based education and biology teacher preparation. I am being supervised by Dr. Maria Helen D. Catalan of UPNISMED. One of my research questions pertains to the future biology teachers' predisposition to teach using inquiry instruction, and I developed an instrument (Test for Inquiry Pedagogy in Science – Biology, TIPS – B) to measure this construct.

Cognizant of your expertise in research instrument development, I am respectfully requesting you to evaluate the instrument's content validity. You may comment on both the items and the options and provide suggestions to improve the items. I am confident that your comments and suggestions will contribute much to the instruments' strength.

As I look forward to your positive response, I thank you very much!

Respectfully yours,

APLER J. BANSIONG
Ph.D. Ed (Biology) Candidate

Appendix C

Letter to TIPS-B Validator

Faculty of Education
University of the Philippines
OPEN UNIVERSITY
Los Baños, Laguna, Philippines

April 28, 2018

PROF. DOROTHY D. SILVA
Faculty
Saint Louis University
Baguio City, Philippines

Ma'am:

Greetings!

I am a Ph.D. in Education (Biology) student at the University of the Philippines Open University working on a dissertation on Inquiry-based education and biology teacher preparation. I am being supervised by Dr. Maria Helen D. Catalan of UPNISMED. One of my research questions pertains to the future biology teachers' predisposition to teach using inquiry instruction, and I developed an instrument (Test for Inquiry Pedagogy in Science – Biology, TIPS – B) to measure this construct.

Cognizant of your expertise in research instrument development, I am respectfully requesting you to evaluate the instrument's content validity. You may comment on both the items and the options and provide suggestions to improve the items. I am confident that your comments and suggestions will contribute much to the instruments' strength.

As I look forward to your positive response, I thank you very much!

Respectfully yours,

APLER J. BANSIONG
Ph.D. Ed (Biology) Candidate

Appendix D

Science Teachers' Inquiry Practices Scale (STIPS)

Dear Respondents:

Try to recall your typical experiences in your previous pre-college and college science classes, and your observations in the science classes of your cooperating teacher. Then using the scale below, try to assess the overall frequency on how each of the following activities had been implemented in these classes.

Scale:
5 = 81 – 100% of the time 4 = 61 – 80% of the time 3 = 41 – 60% of the time
2 = 21 – 40% of the time 1 = 0 – 20% of the time

CHARACTERISTICS: A. My/The science teachers:	Science Courses		Field Study
	Pre-college	College	
1. create a classroom culture that encourages positive scientific attitudes and habits of mind.			
2. provide opportunities for metacognitive processes			
3. stimulate and nurture students' curiosity			
4. limit the use of lecture and direct instruction to occasions where the lesson cannot be taught through hands-on or inquiry-based instruction			
5. demonstrate flexibility by balancing and mediating their preplanned lessons and questions with the activities and directions prompted by student questions			
6. assess students' prior knowledge at the start of the lesson and adjusts teaching accordingly			
7. make learning relevant and meaningful by taking students interest into account and basing lessons on students' prior suppositions			
8. use counterintuitive demonstrations and discrepant (*puzzling, unusual, surprising*) events to pose contradictions and challenge students' previously held beliefs			
9. use inquiries and investigations to "anchor" new information to previously held knowledge.			
10. model inquisitive actions by posing prompting and probing questions as well as asking questions that require higher-level and critical thinking skills			
11. refrain from divulging the answers and pose prompts to clarify students' questions			
12. arrange students' desk for collaborative work in small groups			
13. move about the classroom and rotate among small groups throughout the lesson			

14. encourage students to design and carry out their investigations.			
15. keep students on-task by having them support and debate their data, evidence, and conclusion.			
16. integrate science content with process skills and problem-solving strategies, as well as technology, environment, etc.			
17. act as facilitator, mediator, initiator, and coach while modeling behaviors of inquiry, curiosity, and wonder.			
18. use primary sources of information (journal articles, etc.) rather than, or in conjunction with a prescribed textbook			
19. encourage communication skills such as speaking and listening			
20. encourage students to use concept maps, graphic organizers, and drawings of models to explain and demonstrate newly acquired knowledge.			
21. assess student performance in a variety of forms			
22. initiate and orchestrate discourse and scientific argumentation			
B. In my teacher/CT's class, the students or I			
23. enjoyed posing questions and demonstrating a desire to learn			
24. showed an interest in science by acting as researchers/investigators			
25. engaged in diligent investigations from their self-generated questions			
26. reflected on and took the responsibility of their learning			
27. persisted in asking questions to clarify and confirm the accuracy of their understanding			
28. Worked respectfully and communicated in collaborative groups			
29. considered skepticism and alternative models or points of view			
30. used claims and unbiased evidence to form explanations and arguments			

Appendix E

Pedagogy of Science Testing Test - Biology Items (POSTT-B) by Cobern, Schuster, Adams, Skjold, Mugaloglu, Bentz, & Sparks (2014).

Dear Respondents:

This assessment is composed of classroom science teaching vignettes similar to teaching practices one can find in any classroom today. Practicing teachers contributed ideas for many of the vignettes; others are based on teacher observations, or science curriculum standards.

As you read each vignette, think about how you might teach science in a similar situation. Respond accordingly.

1. Frog dissection

Mr. Goodchild is doing a frog dissection with his 8th graders to help teach them about anatomy.

Thinking about how you would teach a lesson, of the following, which is most similar to what you believe is the best way to incorporate a dissection into a lesson?

A. It should be used as a stand-alone, step-by-step activity for students to explore the frog's anatomy and raise discussion questions on their own.

B. It should be used as a follow-up step-by-step student activity after Mr. Goodchild explains exactly what students will need to notice about the frog anatomy.

C. It should be used as a step-by-step student activity while answering probing questions, followed up by teacher-led discussion and clarifications.

D. It should be used as a step-by-step demonstration by Mr. Goodchild while he explicitly points out what students need to know about frog anatomy.

2. Organisms respond to the environment

Ms. Pendleton wants to teach her 1stgrade students that living organisms respond to their environment. The students experimented on how earthworms respond to their environment. Then in small groups, they discussed a series of questions about the experiment. Ms. Pendleton now needs to wrap up the lesson.

Of the following, which one is most similar to how you would wrap up this lesson?

A. Have the students come up with a general conclusion based on the evidence they gathered from their earthworm experiment, guiding them toward the concept objective.

B. Restate the concept objective for the students, and ask students to provide supporting evidence from their earthworm experiment.

C. Have students report their conclusions based on the evidence gathered from their earthworm experiment.

D. Restate the concept objective for the students, relating it to the observations they gathered in their earthworm experiment.

3. Structure and function

Mr. Danzit will be teaching his 3rd-grade students a lesson on "structure and function" as applied to digestive systems. He has a set of pictures showing the mouths of different animals, including a finch beak, a dog jaw with teeth, and a horse jaw with teeth. He also has a chart that he can distribute to the students, which will allow them to fill in information about what each of these animals can and cannot eat.

Thinking about how you would teach this lesson, of the following, which is the best statement on how Mr. Danzit should begin the lesson?

A. Mr. Danzit should begin the lesson by carefully explaining the concept of structure and function as it relates to the digestive system, specifically mouthparts. He should then ask the students to fill out the chart using the pictures and his discussion as a guide.

B. Mr. Danzit should allow the students to explore a set of photos showing animal mouths. He should then have the students write their own stories about how these animals are similar and different, including what they eat.

C. Mr. Danzit should begin the lesson by carefully explaining the concept of structure and function while helping students fill in their charts, so they can see examples of this concept as it relates to digestive systems.

D. Mr. Danzit should begin the lesson by showing his students a picture of a shark mouth, asking the student what this animal might eat. After a discussion, he should give each student a copy of the chart and the other pictures, asking students to complete the chart based on their early discussion.

4. Field trip

Ms. Piper is taking her 3rd-grade class to the local nature center. Because they are currently studying food webs, she would like to use the field trip as a way to learn more about this topic.

Thinking about how you would teach, of the following, how would you most likely use a field trip to teach students about food webs?

A. I would inform them that on our upcoming field trip, they will be looking for examples of food webs. During the field trip, students could make their list of interactions they observe relating to food webs, which we would discuss later as a group.

B. I would inform students before the field trip that we are going to look for specific examples of food webs, providing them a checklist of interactions they should see. During the field trip, I would point out to them interactions, having them mark off each as we go.

C. I would not tell students exactly what to look for during the field trip but would ask them to make observations about any of the interactions they see between organisms. Afterward, we could discuss what they saw relating to food webs.

D. I would inform students before the field trip that we are going to look for specific examples of food webs, providing them a checklist of interactions they should see. During the field trip, students could look for those examples and mark them off as we go.

5. Predator and prey

Mr. Peoples is conducting a unit on food chains and is about to introduce his 7th-grade students to predator/prey relationships. He has a good computer simulation game for this subject that he can use with his class.

Thinking about how you would teach this lesson, of the following, which is the best advice for conducting this lesson?

A. Mr. Peoples should explain to his students that balance typically exists in nature such that the numbers of predators and their prey are related. For example, he can tell them that a rabbit population will increase if disease reduces the coyote population in the same region. He should then project the simulation game to demonstrate relationships between rabbit and coyote populations.

B. Mr. Peoples should explain to his students that balance typically exists in nature such that the numbers of predators and their prey are related. For example, he can tell them that a rabbit population will increase if disease reduces the coyote population of the same region. Using the computer simulation game, he should have the students monitor and record the rabbit levels over a simulated ten-year period during which the population of coyotes rises and falls, so that they can confirm the predator/prey concept he explained.

C. Mr. Peoples should ask what would happen with rabbits if many coyotes died suddenly of disease. After some discussion, Mr. Peoples should suggest that the students explore their ideas using the computer simulation game he has for this subject, by recording yearly counts over a simulated period of ten years. The students will then have data to be used in a class discussion on predator/prey relationships.

D. Mr. Peoples should begin by asking the students what they know about predators and prey. Without responding other than to encourage their ideas, Mr. Peoples should then show them the computer simulation game he has for this subject and invites them to use the simulation in any way they wish to explore their ideas. The lesson would end with students writing up their findings.

(6) Inheritance

Mr. Montgomery was teaching his 7th graders about inheritance. After introducing the topic and demonstrating how to use a Punnett square to determine genotypes and phenotypes of possible offspring, he asked students to solve a variety of application problems in small groups.

Thinking about how you would teach, how would you end this lesson?

A. Since students would have already discussed the problems in their small groups and developed their understanding of the topic, I would end the lesson here.

B. I would give the students the right answers to the problems.

C. I would ask the students to explain their answers to the class. Drawing on their explanations, I would guide them to the correct answers.

D. I would review the correct answers to the problems with the students as a class discussion

(7) Succession

Ms. Tutt's 6th-grade class has just finished an introductory lesson on plant succession. The students now understand that succession can be initiated either by the formation of new, unoccupied habitat (*primary succession*) or by some form of

disturbance of an existing community (*secondary succession*). She is now considering the use of a follow-up activity at a green space near campus and has several options.

Thinking about how you would teach, of the following, which is most similar to what you would do?

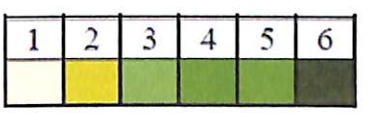
A. Provide the students with a map of the green space demarcating succession. I would then walk the students through the succession areas, pointing out the plant life specific to each area.

B. Provide the students with a map of the green space demarcating succession. The students' task would be to identify the types of plant life in each succession area.

C. Ask the students if they thought they could identify succession and how they would do it. Then we would go to the green space, and the students' task would be to map out succession at the green space, developing and documenting their maps.

D. Take the students to the green space and ask them to observe as much as they could corresponding to our recent studies on succession. I would leave it to the students' imaginations on how best to use their observations of a real succession environment, and how to document those observations.

(8) Photosynthesis



Ms. Hamid has been teaching her 8th-grade students about photosynthesis, and in particular, that chlorophyll production in plant leaves is light-induced. She sets up an example to illustrate this. She has placed fast-growing seedlings where they are exposed to different levels of light intensity. The students observe the growing plants over several days and estimate the amount of chlorophyll using a color chart to record leaf color. They record their data in their science notebooks and on a classroom data table. On the last day, Ms. Hamid reviews the role of light in chlorophyll production, as illustrated by the activity.

Thinking about how you would teach this topic, of the following, which is the best evaluation of her lesson?

A. This is a good lesson design overall because Ms. Hamid begins with an explanation of the concepts; she wants the students to learn, followed by an activity for students to confirm that chlorophyll production is light-induced.

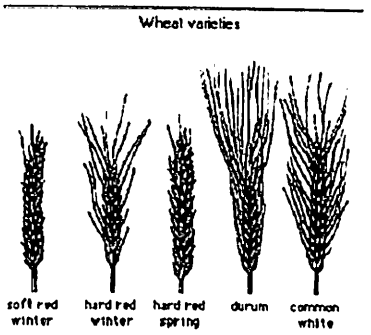
B. Ms. Hamid begins appropriately with an explanation of the concepts she wants the students to learn. This being so, it is not clear that the activity is needed, especially since it requires so much class time.

C. Ms. Hamid's approach is too pre-organized and prescriptive. It would be better for students themselves to decide how to set up plants and lights, see what happens, and figure out a way to compare chlorophyll production in the leaves.

D. The instructional sequence would be better if the students do the plant observations first, showing that chlorophyll is light-induced, after which Ms. Hamid can explain the process more fully.

(9) Varieties of wheat

Ms. Coker will be teaching her 3rd graders a unit on edible plants. Today's topic is that wheat comes in many different varieties.



Thinking about how you would teach, of the following, which is most similar to how you would use transparency, such as the one shown in this diagram?

A. I would give my students many types of wheat to sort by appearance. Once the task was completed, I would show the transparency and ask the students how their sorting compared with the pictures on the transparency. I would then conclude the lesson by reviewing the intended learning outcome.

B. I would give my students samples of wheat to look at. As I explained the concepts to be learned, I would have them identify the wheat samples by referring to the transparency.

C. It is important to state the intended learning outcome at the start of the lesson, so I would use the transparency as I explain the concepts to be learned, and show them an example of a wheat stalk of each kind.

D. I would not use a transparency such as this, as it would make the lesson too teacher-directed. I would give my students samples of wheat to sort by characteristics of their choosing and then record their results. The lesson would conclude with a discussion of their findings.

(10) Animal sorting

Ms. Lodge is teaching her kindergarteners that the process of sorting involves identifying characteristics and grouping accordingly. She gave each student a set of 10 animal cards and asked them to sort the animals into groups with similar characteristics.
Thinking about how you would teach, of the following, how would you make this lesson more effective?

A. This lesson would be more effective if Ms. Lodge started by explaining the process of sorting and then allowed the students to sort the animals based on characteristics.

B. I wouldn't change this lesson; the students choose their approach to sorting.

C. This lesson would be more effective if Ms. Lodge explained and demonstrated the process of sorting using animal cards.

D. This lesson would be more effective if Ms. Lodge concluded by drawing on the students' work to highlight the process of sorting.

(11) Fossils provide evidence for change

Ms. Jefferson's 6th grade is learning about how fossils can provide evidence of how life has changed over time. She poses a question: "How do fossils help show us changes on Earth over time?" Ms. Jefferson continues by asking the students to examine several different rock samples, all containing different types of fossils.

Thinking of how you would teach this lesson, of the following, how would you evaluate this lesson so far?

A. The students are asked to make observations before being instructed on what to look for. Instead, Ms. Jefferson should have described how fossils provide evidence of change over time, using the fossil samples as examples to demonstrate her point.

B. The students are asked to make observations before being instructed on what to look for. Instead, Ms. Jefferson should have described how fossils provide evidence of change over time, and then have the students examine the different rock samples to verify Ms. Jefferson's explanation.

C. This lesson is fine the way it is. Ms. Jefferson states a question for the students to think about and then provides materials the students can utilize to explore this question.

D. Ms. Jefferson should not have posed such a detailed question before student investigations. The students should have been allowed to examine the rock samples and, as a class, discussed their ideas about the fossils.

(12) Hand sanitizers: a teachable moment

Ms. Simmons' 8th-grade class is learning about where bacteria are found and their influence on humans, when one of the students asks, "Why do we use hand sanitizers?" Ms. Simmons is not sure of the best way to respond to this student's question concerning the lesson objectives.

Thinking about how you would teach, of the following, which is most similar to how you would deal with this teachable moment?

A. I would encourage the students to think of ways to answer this question, and give them time and materials to pursue their investigations.

B. I would give my students a brief explanation of how hand sanitizers work and tie this information to what we had been studying about bacteria. Then we would get back to the lesson objectives.

C. I would give my students a brief explanation of how hand sanitizers work and then ask my students if they could think of ways to test their effectiveness. I would conclude the lesson by tying their ideas back to the objectives.

D. I would elicit the students' ideas about the question, including how to test those ideas. We would try some of those tests, and I would conclude the lesson by tying their findings back to the objectives.

(13) Plant misconceptions

The students in Mr. Gordon's 3rd-grade class are learning how plants grow, what parts plants are composed of, and what they can be used for. Mr. Gordon has the students create a book about what they are learning. As students work on their books, he notices that some have the misconception that plants "eat dirt." What can Mr. Gordon do to address this misconception?

Thinking about how you would teach this lesson, of the following, which offers the best advice for dealing with this misconception?

A. Mr. Gordon should explicitly point out the evidence that indicates plants do not eat dirt. He should then reinforce this with an additional short activity that illustrates his point.

B. Mr. Gordon should explicitly point out the evidence that indicates plants do not eat dirt. The students can then revise their books to match this understanding.

C. Mr. Gordon should ask students to develop and conduct their investigations into what plants eat.

D. Mr. Gordon should have students conduct a short activity that demonstrates that plants do not eat dirt. He should then ask them to challenge their ideas about what plants eat, given the results.

(14) Linnaean system of classification

Mr. Clark is introducing his 8th-grade students to the classification of organisms. He provided them with pictures of 25 organisms, representing the five kingdoms, and had students group them according to observable characteristics. The class then discussed their ideas only to discover that they had chosen different characteristics on which to group the organisms. At this point, Mr. Clark told the class that scientists eliminated confusion over the classification of living things by adopting the Linnaean system of classification as a universal standard. Mr. Clark then explained that in this system, more characteristics are used than what can be seen in a photograph, such as what an organism eats.

Thinking of how you would teach, of the following, how would you evaluate Mr. Clark's introductory lesson?

A. Having students try classifying on their own is good because they will better appreciate the challenges of constructing a universally accepted classification system.

B. Instead of first having students group the pictures in their way, which could be confusing, he should have explicitly explained the Linnaean system of classification, and then had his students apply the system to the organisms in the photographs.

C. Instead of having students group the pictures in their way, which could be confusing, he should have explicitly explained the Linnaean system of classification, using the photographs as examples.

D. This is a good lesson, except, rather than an explicit discussion of the Linnaean system, Mr. Clark should have had his students explain their reasoning for how they classified the organisms.

(15) Chlorophyll

"Chlorophyll is a natural pigment found in green plants. It is the primary pigment that absorbs light energy from the sun for photosynthesis. This energy is then used by the plant to synthesize carbohydrates from carbon dioxide and water." This is what Ms. Pozner's 8th-grade life science textbook says, and she is wondering how best to teach a lesson on chlorophyll and the process of photosynthesis. She has several ideas, but each one has limitations.

Thinking about how you would teach, of the following ideas that Ms. Pozner is considering, which is most similar to how you would teach this lesson? I would...

A. Have the students read the textbook section on photosynthesis and chlorophyll. We would then have a classroom discussion where we draw out and clarify the important points. I would then summarize the concepts for the students.

B. Have the students read the textbook section on photosynthesis and chlorophyll. I would then explain these concepts while showing relevant slides.

C. Read aloud the textbook section on photosynthesis and chlorophyll to the class. Then I would explain these concepts while showing relevant slides.

D. Have the students use the textbook and online resources to investigate photosynthesis and the role of chlorophyll. I would then have the students summarize their findings for the class.

(16) Microbes

Mr. Green is introducing his 3rd-grade students to the idea that tiny living microbes are found all around us. He has his students create a list of places where they think

that microbes would or would not be found. The students then share their lists while Mr. Green writes their ideas on the board.

Thinking about how you would teach, of the following, which is most similar to how you would follow up on this introductory activity?

A. I would applaud the students for their participation, and then end the lesson by having them write a short paragraph on where they believe microbes can be found.

B. I'd ask the students what generalizations they might reach based on the lists they created. Then, based on the students' ideas, I would confirm the point that microbes can be found almost everywhere in daily life.

C. I would explain that microbes can be found almost everywhere in daily life. Then I would use students' ideas from their lists for support so that the lesson objective is clearly tied to the students' ideas.

D. Rather than beginning the lesson this way, I would have clearly stated what students were to learn before engaging in any activities.

Appendix F

Attitude Scale for IBSI Use (ASIU) developed by Evrekli, Inel, Balim & Kesercioglu (2010).

Dear Respondents,

Read the following items carefully. Then check on the column that appropriately describes what you feel about inquiry-based instruction as a teaching approach.

ITEMS	Yes	Somewhat	No
1. I would do anything to learn about inquiry-based instruction (IBSI)			
2. IBSI is an approach that deserves much emphasis.			
3. IBSI is my desired teaching approach.			
4. I am not interested in the IBSI approach.			
5. I like the IBSI approach.			
6. I like using the IBSI approach in my classes			
7. I do not enjoy performing activities concerning the IBSI approach.			
8. The IBSI approach is not interesting for me in any way.			
9. I like reading books about the IBSI approach			
10. I would like to use the IBSI approach in my future teaching.			
11. I like informing others around me about the IBSI approach.			
12. IBSI is a useful teaching approach			
13. I believe that I can benefit much from the IBSI approach			
14. I would like to conduct research on the IBSI approach			

Appendix G

Modified Educational Philosophies Self-Assessment Scale (©Cohen, 1999)

Dear Respondents,

This questionnaire will help you recognize and name your educational philosophy. Respond to the given statements on a scale from 1, "Strongly Disagree," to 5, "Strongly Agree." Record the number of your answer along with the question number for scoring.

1	The curriculum should be universal; a given body of information about western civilization should be taught through discussion and lecture.	1	2	3	4	5
2	Students are makers of meaning and construct their understandings from active experience, rather than through transmission from teachers.	1	2	3	4	5
3	The curriculum should not be predetermined; rather, it should spring from students' interests and needs.	1	2	3	4	5
4	It is necessary and good that schools instill traditional values in students.	1	2	3	4	5
5	Schools exist to provide practical preparation for work and life, not to nourish personal development.	1	2	3	4	5
6	Teaching the great works of literature is less important than involving students in activities to criticize and shape society.	1	2	3	4	5
7	Teachers, rather than imparting knowledge, are facilitators of conditions and experiences so students can construct their understandings.	1	2	3	4	5
8	The aim of education should remain constant regardless of differences in era or society. It should not vary from one teacher to another.	1	2	3	4	5
9	Schools should encourage student involvement in social change to aid in societal reform.	1	2	3	4	5
10	The emphasis in schools should be hard work, respect for authority, and discipline, rather than encouraging free choice.	1	2	3	4	5
11	Schools should guide society toward significant social change rather than merely passing on traditional values.	1	2	3	4	5
12	Teachers should concentrate on conveying a common core of knowledge rather than experimenting with modifying the curriculum.	1	2	3	4	5
13	The curriculum should focus on basic skills instead of students' interests.	1	2	3	4	5
14	Conflicts to current understandings trigger the need to learn and to make meaning.	1	2	3	4	5

15	Rewards controlled by the external environment lead to and result in all learning.	1	2	3	4	5
16	Advocating for the permanency of the classics is a vital part of teaching.	1	2	3	4	5
17	Perceptions centered on experience should be emphasized, as well as the freedom and responsibility to achieve one's potential.	1	2	3	4	5
18	Education should help drive society to better itself, rather than restricting itself to essential skills.	1	2	3	4	5
19	Teachers should encourage democratic, project-based classrooms that emphasize interdisciplinary subject matter.	1	2	3	4	5
20	A knowledgeable individual facilitates or scaffolds learning for a novice based on understanding the learner's developmental level and the content to be learned.	1	2	3	4	5
21	Successful teaching creates an environment that controls student behavior and assesses the learning of prescribed outcomes.	1	2	3	4	5
22	The greatest education centers mainly around the student's exposure to great achievements in subjects such as arts and literature.	1	2	3	4	5
23	Learning requires modifying internal knowing structures to assimilate and accommodate new information.	1	2	3	4	5
24	The role of the teacher is to create an atmosphere that rewards desired behavior toward achieving goals and extinguishes undesirable behavior.	1	2	3	4	5
25	The primary goal for educators is to establish environments where students can learn independently through purposeful reflection about their experiences.	1	2	3	4	5
26	Principles of reinforcement (anything that will increase the likelihood that an event will be repeated) and contiguity (how close two events must be chronologically for a bond to be created) are pivotal to explaining learning.	1	2	3	4	5
27	Students' involvement in choosing how and what they should learn is central to education.	1	2	3	4	5
28	One's behavior is shaped by one's environment; elements within that environment (rather than the individual learner) determine what is learned.	1	2	3	4	5
29	The most distinctive quality of human nature is the ability to reason; for this reason, the focus of education should be on developing intellect.	1	2	3	4	5
30	Learning should guide students to active participation in social reform.	1	2	3	4	5

Appendix H

Inquiry Use Self-Efficacy Scale (IUSES) based on the Reformed-Teaching Self-Assessment Inventory (ITSAI – Isola & Wenning, 2007) and McGill Enactment of Inquiry Questionnaire-Self-Efficacy-Teachers (MEIQ-SET, Chichekian & Shore, 2016)

Dear Respondents,

Please rate your self-efficacy (level of confidence) of doing each of the following from 0 ("definitely not true of me") to 10 ("definitely true of me") by encircling the corresponding number. Your responses will be coded and will be kept confidential.

ITEMS	Not true of me										Very true of me
1. I CAN use strategies and activities that show respect for students' prior knowledge and their preconceptions or misconceptions found within that knowledge.	0	1	2	3	4	5	6	7	8	9	10
2. I CAN design strategies and activities that allow students to use their prior knowledge to explain or predict phenomena and then resolve any results or answers that are surprising to them.	0	1	2	3	4	5	6	7	8	9	10
3. I CAN provide opportunities for students to explore first before they are provided with formal presentation (lecture or demonstration, etc.)	0	1	2	3	4	5	6	7	8	9	10
4. I CAN modify my lesson depending on the ideas or questions originating from students.	0	1	2	3	4	5	6	7	8	9	10
5. I CAN modify my lesson based on the results of my formative assessment strategies (checks for understanding, quick questions, etc.)	0	1	2	3	4	5	6	7	8	9	10
6. I CAN pose questions or problems that encourage students to seek and value different ways to investigate or solve a problem	0	1	2	3	4	5	6	7	8	9	10
7. I CAN design lessons that engage students as members of a "learning community," intellectual rigor, constructive criticism, and the challenging of ideas are valued.	0	1	2	3	4	5	6	7	8	9	10
8. When I teach, I CAN focus on the fundamental concepts of the subject. There are always some significant	0	1	2	3	4	5	6	7	8	9	10

scientific or mathematical ideas at the heart of each lesson.											
9. I CAN implement lessons that emphasize the strong inter-relatedness (how similar or different from previous concepts) of scientific thinking.	0	1	2	3	4	5	6	7	8	9	10
10. I CAN see quickly what students are trying to say, how it connects with science concepts, and bring up questions, ideas, or examples that help the student clarify their thinking.	0	1	2	3	4	5	6	7	8	9	10
11. I CAN help and encourage students to follow general guidelines, laws, or theories to develop a solution (a model). In my future lessons, relationships or patterns are represented in abstract or symbolic ways (graphs or equations)	0	1	2	3	4	5	6	7	8	9	10
12. I CAN use many different real-world phenomena as teaching tools to help students understand basic science and math concepts, not just to entertain them or keep their attention.	0	1	2	3	4	5	6	7	8	9	10
13. I CAN require students to use a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, lab materials, etc.) to represent phenomena.	0	1	2	3	4	5	6	7	8	9	10
14. I CAN allow the students to make predictions and/or hypotheses, and they are encouraged to devise means to test and then validate or reject these predictions/hypotheses.	0	1	2	3	4	5	6	7	8	9	10
15. I CAN let students be actively engaged in thought-provoking activities that often involve the critical assessment of procedures. Students actively think about what they are doing and about how they were doing. From here, they are clarified on the next steps in their investigation.	0	1	2	3	4	5	6	7	8	9	10
16. I CAN require students to be reflective about their learning. Student reflections could start with questions like, "How did I used to think about this?" "What caused me to change my mind?" "What made it difficult for me to understand this?" etc.	0	1	2	3	4	5	6	7	8	9	10

17 I CAN use a range of assessment strategies that measure the depth of student understanding and the application thereof.	0	1	2	3	4	5	6	7	8	9	10
18. I CAN require students to communicate their ideas to others using a variety of means and media (Making presentations, brainstorming, critiquing, listening, making videos, group work, etc.)	0	1	2	3	4	5	6	7	8	9	10
19. I CAN implement a lesson or activity where there is a high proportion of student talk (student discussion), and a significant amount of it occurs between and among students.	0	1	2	3	4	5	6	7	8	9	10
20. I CAN require that students always respect what each student has to say. (Students express their ideas and opinions without fear of censure or ridicule)	0	1	2	3	4	5	6	7	8	9	10
21. I CAN lead or direct unanticipated behavior to rich learning opportunities.	0	1	2	3	4	5	6	7	8	9	10
22. I CAN act as a resource person, working to support and enhance student investigations and problem-solving.	0	1	2	3	4	5	6	7	8	9	10
23. I CAN be called "teacher as a listener" (This metaphor describes a teacher who is often found helping students use what they know to construct further understanding)	0	1	2	3	4	5	6	7	8	9	10
24. I CAN be approachable and encouraging to students. Students can come to me for consultation/clarifications.	0	1	2	3	4	5	6	7	8	9	10

Appendix I

Test for Inquiry Pedagogy in Science – Biology

Dear Respondents:

This assessment is composed of classroom science teaching vignettes similar to teaching practices one can find in any classroom today. As you read each vignette, think about how you might teach biology in a similar situation. Respond accordingly.

1. You are a high school science teacher about to teach units on sexual reproduction in plants. Which of the following would be most similar to how you are to teach flower diversity?

A. I will let my students bring five different flowers. I will then ask them to observe and sketch the floral parts of each flower and label the parts using a labeled diagram as reference material. Then they will compare the flowers using either a conceptual grid or a Venn diagram. They will then present their outputs in class. I may input some key points to improve their presentation.

B. Using a PowerPoint slide or transparency, I will show a labeled picture of a typical flower. I will emphasize that floral parts are categorized as reproductive and accessory structures, and flowers are categorized on the presence of these structures. Then I will let the students bring out the flower samples they were asked to bring, and complete a checklist on flower species and the floral structures present in these samples. Then they will be asked to give a conclusion on flower diversity.

C. I will first give a lecture on the parts and functions of a flower, pointing out the differences between complete and incomplete flowers, and in between perfect and imperfect flowers. Then I will let students bring out the flowers they were assigned to bring, and classify their flower samples as complete, incomplete, perfect, or imperfect.

D. As an assignment, students bring a labeled diagram of a complete flower and five different kinds of flower samples. I will ask them to explore as much as they can about the flowers. They can observe the flowers' external and internal structures. I will then require them to produce a poster that will depict the theme "Floral diversity" and exhibit their outputs for peer critiquing and/or class discussion.

2. To begin a lesson on the characteristics of living things, Mr. Santos lighted a piece of candle and told the class that this lighted candle is one of his favorite pets. This drew some surprised reactions from the class, as students hold the notion that the word pet is used only to living things. Then Mr. Santos asked why a lighted candle cannot be a pet, and why it can't be a living thing even if it shares some

characteristics of life. Several reactions arose from the class, and this led to an active discussion on the characteristics of living things.

If you were in the situation of Mr. Santos, how would you teach the topic?

A. I will teach the lesson in the same way as Mr. Santos.

B. I would use a different strategy. I will instead show pictures of organisms depicting some characteristics of life, such as birds flying, a lizard with cricket in its mouth, or a metamorphosing butterfly. Then I will ask the students to identify the characteristic of life depicted in each picture. Then I will present and explain the other characteristics of living things. I will then ask questions to check for understanding, or extend the lesson.

C. I will teach the lesson in the same way as Mr. Santos. However, I will not ask them the same probing question, i.e., "Why is a lighted candle non-living thing?" Instead, I will let them ask any question about the demonstration and let them provide answers to this question through a mini- position paper, or to give some points and counterpoints as if they are to join a debate. Some issues (misconceptions, naïve ideas) will be clarified, and additional discussions will be provided after.

D. I will start the lesson differently. I will present through PowerPoint the nine characteristics of living things, pointing out the difference between living and non-living things, and in between plants and animals. To check for understanding, I will divide the class into two groups. One group will act out a characteristic of life, and the other group will guess what characteristic is shown. The time it will take the other group to guess will be noted. The groups will then change rules. After five rounds, the group with the lowest time record wins the game.

3. Mrs. Perez is preparing a lesson on substance transport in cells, and she wanted particularly to demonstrate the principle that temperature affects the rate of diffusion. In the science laboratory are celery stalks, food coloring, beakers, water heater, ice, and cutters available. If you are to advise Mrs. Perez on what teaching approach to use, which one is most similar to what you will recommend?

A. I will advise her to explain the factors affecting the diffusion rate carefully. I will let her point out that temperature is one of the factors that affect the diffusion rate. To prove the effect of temperature on the rate of diffusion, I will advise her to demonstrate the principle by soaking freshly cut celery stalks in colored water of varying temperatures (i.e., 6°C, 12°C, and 18°C). For her to cut down the demonstration time, I will advise her to be ready with a ready-made result. She will then let the students compare the length traveled in the stalks soaked at different temperatures.

B. I will advise her to ask the question, "What is the effect of temperature on the rate of diffusion?" Then advise her to guide her students to explore the question themselves by soaking some celery stalks in colored water of varying temperatures (i.e., 6°C, 12°C, and 18°C). Then after some a few minutes, the students will now be asked to get the stalk out of the colored water then measure the length the dye has traveled along the stems. From this evidence, they will state a conclusion that will relate the effect of temperature on the rate of diffusion.

C. I will advise her to assign her students to research in advance the factors affecting the rate of diffusion. Then, as a motivational activity during her demonstration lesson, she will be advised to give a graded recitation in the form of a game. After that, she will collect the assignment, revisit the different factors, and provide additional information on the topic. I will also suggest that the students will verify the principles at home by comparing the amount of time a teaspoon of coffee powder will dissolve in hot water and lukewarm water.

D. I will advise her to ask the question, "What are the factors that affect the rate of diffusion?" Then with the use of all the materials available in the lab, her students in small groups will plan an investigation to explore the problem. They will first show the plan and seek approval from the teacher. I will advise Mrs. Perez not to suggest changes in the plan, unless some procedures violate safety measures. Upon approval, students will now implement their plans and obtain results. They will report in their findings through a mini scientific paper. There will then be some class discussions on the findings after the exploration.

4. You are to teach about the structure and function of the human heart, and you wanted to touch on one of the fundamental principles of biology, the complementarity between structure and function. Which of the following strategies is most similar to how you will teach this fundamental principle?

A. I will let the students study a human heart model and carefully explore its parts. I will then point out the parts, particularly the four heart chambers. I will let them compare the relative thickness of the walls in the upper and lower chambers, and the left and right chambers. I'll inform them that some chambers are blood-receiving chambers, and others are blood-pumping chambers. I will also prompt them to relate the relative thickness of the chamber walls with the force they require to perform their functions. The students will then come up with a statement that will identify which chambers are for pumping blood, and which are for receiving blood.

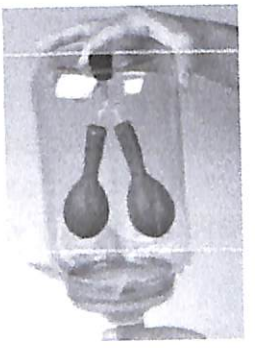
B. I will give worksheet where students will label a blank illustration of the human heart. Then they are to research on the functions of each chamber, valve, and associated blood vessels. I will assign some students to report on the functions of each part. I will then ask some probing questions, and explain that the ventricular walls are thicker than the atrial walls because the ventricular walls need a greater

force to pump blood out of the heart. I will now relate this concept to the principle of structure fits function.

C. I will show a video on the structure and function of the human heart. I will pause or rewind the video if I feel that the idea presented requires more emphasis or explanation. After the video show, I will give a worksheet for the students to complete individually. We will then correct the worksheet and then process the activity. I will provide some notes as supplementary materials when needed.

D. I will do the same activity as A, except that I will not provide any prompt on the relationship between chamber wall thickness and force required. I will then let students explain how the heart chambers and their function illustrate the principle of the complementarity between structure and function.

5. Teacher Roy's class has been learning about the animal respiratory system. But he wanted to emphasize that breathing is an involuntary movement, controlled by the brain's respiratory center. Also, he wanted to further explain on the physiology that breathing movements are brought about by the action of muscles and by gas diffusion principles and Boyle's law.



If you are to substitute Teacher Roy in his class, how are you going to implement your lesson, considering the same learning goals as Teacher Roy?

A. I will ask students to construct a working lung model similar to the illustration shown. In small groups, I will ask them to explore the model by pulling the large balloons back and forth and observe what movements take place in the small balloon inside the chamber. Then I will let them explain the physiological processes in the lung cavity that result in inhalation and exhalation. I will hint that they refer to the gas diffusion principles and Boyle's law to give support to their answers.

B. I will give a textbook-aided lecture on the mechanism of breathing in humans. I will emphasize that breathing is an involuntary action, controlled by the diaphragm and the intercostal muscles. I will then lead them to the step-by-step physiological processes that result in inhalation, then exhalation. I will use Boyle's law and the gas diffusion principle to expound on the concept. I will then demonstrate the processes using a working lung model.

C. I will assign some students to read about the mechanism of breathing in humans, specifically on what causes air to enter or leave the lungs. To check the assignment, I will provide a worksheet where students arrange the physiological processes that lead to inhalation, then exhalation. I will provide additional explanations as needed.

D. I will let students explore their working lung models. Then, I will facilitate a review by asking them which part of the human lungs does each structure in the model represents. Students will then explore what actions must be done in the model to cause inhalation and then exhalation. I will define gas diffusion principles and Boyle's law. As an output, I will give a completion type worksheet such as "During inhalation, the _____ and the _____ contract, resulting to increased pressure in the _____."

6. The aim of Ms. Elsa's class Grade 5 science class is to introduce the concept of food chains. She began the lesson with the following vignette: "Ben was telling about some things he saw happening in and around a local pond. He said he had seen tiny water fleas eating algae, a heron with perch in its beak, minnows eating water fleas, and a perch chasing minnows around the pond." Then she let the students connect using arrows the organisms according to what they eat and what eats them. They were then informed that the diagram they draw is an example of a food chain. Then the students were asked to give their definitions of a food chain. (Take book definitions were not encouraged). The class analyzed the outputs, and Ms. Elsa facilitated the lesson extensions. If you were to teach the same lesson as Ms. Elsa, which of the following strategies will be most similar to how you will deliver your lesson?

A. For students to have a uniform knowledge base, I will provide a formal definition of a food chain. Then I will show diagrams of different food chains (grazing food chain, detritus food chain, aquatic and terrestrial food chains). I will introduce the concept of trophic levels in the discussion. I will end my presentation with some graded recitations.

B. I will ask the students to recall what they have learned about food chains or ask them to read the topic in advance. I will also assign them to bring a diagram of the four kinds of food chains. During the lesson, I will emphasize on such key concepts as trophic levels and types of food chains. As a practice activity, I will provide a worksheet where students construct a food chain from a list of ten aquatic organisms and all organisms they eat. Here, students will be led to realize that a food chain can become interconnected, forming a food web.

C. I will provide time for students to read their textbooks on food chains and food webs. Tell them to study the accompanying diagrams. I will then ask some probing questions and emphasize key points. To infuse some fun after the reading activity, I will ask students to act out representative organisms like eagles, frogs, snakes, grass, grasshopper, bacteria, etc. Then they will be asked to link themselves up to the organism they will naturally eat, forming a "food chain." I can structure the activity such that it could be a competition among different groups.

D. I will deliver the lesson the same way as Ms. Elsa delivered hers.

7. Which of the following is most similar to how you are to teach a lesson on lactic acid fermentation in vertebrate muscles?

A. I will provide a simplified equation of lactic acid fermentation, showing the major reactants and their products. I will explain the fate of the product, and show how the lactic acid is converted into safer by-products. I will then relate these occurrences with the concept of oxygen debt and muscle fatigue/cramps occurring during heavy exercise.

B. I will ask the class to work in pairs. I'll then assign one partner to record how many times the other will raise his/her hands in thirty seconds. Without the doer resting, they will repeat the procedure five times. Let them record the results, and the doer rests for five minutes. Then, ask the pair to repeat the same procedure, but provide the doer a three-minute rest in between trials. Ask them now to compare the results and explain the trend. I'll use this activity as a springboard to teach about lactic acid fermentation in vertebrate muscles.

C. I will give a short lecture on lactic acid fermentation in vertebrate muscles. Then I will cut the lecture for students to do jumping jacks. They will do the action as long as they can. I'll wait until everyone gets tired and has stopped. Then after providing a short time for resting, I will continue the lecture, emphasizing that fatigue is caused by lactic acid accumulation in muscles.

D. I will ask the students if they have experienced muscle cramping or fatigue. Ask them when they usually experience cramping and how did they recover from the condition. Students may share answers to the class. I will then use this sharing session as a springboard for teaching about lactic acid fermentation in vertebrate muscles.

8. Mr. Reyes is teaching about the presence of villi and microvilli in the walls of the small intestines. He wants to teach the lesson in a way that is both understandable and memorable to his students. Thinking about your teaching, which is most similar to how you would teach the same lesson?

A. I would state that the villi and the microvilli are fingerlike projections that increase the surface area for absorption in the small intestines. I will illustrate the point by drawing the cross-section of an intestine with villi and a hypothetical one without villi. Then I will emphasize the point by asking which of the two structures is more efficient in absorbing nutrients.

B. I will draw two lines covering the same lengths, except that one line is straight while the other has folds. Then using a thread to trace the lines, the student will measure and compare the two lengths. Then I will guide the students as they relate their observation with the functions of villi and microvilli in the intestinal walls.

C. I will begin the lesson by stating that the purpose of the villi and the microvilli, i.e., for an increased surface area for nutrient absorption. Then I will simulate this principle by conducting a demonstration that compares the amount of water absorbed by toilet papers with and without folds.

D. During the science period, I will direct the students to design and implement an activity or experiment that will compare the amount of water absorbed by folded and unfolded paper towels covering the same surface area. They will be provided with graduated cylinders, water, beaker, and paper towels. They are to collect data and report their results. They will now be allowed to consult references for them to relate their activity with the functions of the villi and microvilli.

9. As a policy in the science department where you are teaching, you are to require a big project for students at the culmination of a unit. You completed a unit in ecology, and you are now in hard up in deciding on what big project you are to require. Which of the following suggestions would you find helpful?

A. A beauty pageant, where candidates model attires made up of recycled materials, and whose Q and A portion revolve on environmental awareness. Winners are chosen based only on the candidates' environmental advocacies, their attires, and their answers in the Q and A.

B. Let students prepare and submit a video documentary that focuses on states of pollution in a given community.

C. Let students come up with research projects on environmental awareness, such as waste disposal and recycling practices among different barangays or among students at various educational levels. Or, they might be asked to device and evaluate the effectiveness of a board game that can be used to enhance recycling practices among different groups of people.

D. Let students propose and implement training on good agricultural practices such as composting, or organic farming, or handicrafts making using recycled materials. Students will submit a terminal report as an output.

10. Ms. Garcia, a new teacher in a local high school, is about to begin a lesson on cellular respiration. Recalling her experience in her biochemistry course in college, she knew that the topic is mind-boggling. She has spent a lot of time thinking about how to start the lesson in a motivating and interesting manner. As a caring master teacher, which of the following teaching procedure is most similar to what you will advise her?

A. Tell her to begin her lesson by asking the class, "In which time of the day will food taste better, in the morning, or the evening?" Then she will explain why food tastes

better in the evening. Use this discussion, to begin with, an interactive lecture on cellular respiration.

B. Tell her to begin the class by letting her students arrange the following words to come up with a sensible statement: **LIVE, EAT, I, TO**. The two possible answers: "I LIVE TO EAT" and "I EAT TO LIVE." After the students are led to a healthy discussion on the issues behind the two statements, she will begin her explanations on cellular respiration.

C. Advise her to tell the class about their topic for the day, which is cellular respiration. Tell her to define cellular respiration, and let her prove that food indeed contains energy by burning a peanut under a set-up that resembles a simplified calorimeter. She will let the students observe what will happen to the temperature of the water and explain the meaning of the change in temperature.

D. Advise her to let the students prepare per small group the following set-up: A test tube containing a thermometer and 10 ml water. Provide them a tong, a dried peanut, and some matches. Then students will completely burn the peanut under the test tube set-up and observe the temperature changes. Ask the class how this activity might relate to the lesson on cellular respiration.

11. Adaptation was the main theme in Sir Joey's junior high school science class. He used to teach physical sciences, and this was his first time handling a biological science lesson. If you were in Sir Joey's situation, how would you deliver your lesson? If your plan of delivery is not in the choices, choose the one that is most similar to your approach.

A. In advance, I will ask some members of the class (to be led by a member of the school's Theater Arts club) to read about adaptation and create a 15-minute theatrical play depicting adaptation as it occurs in nature. After the play, I will facilitate the processing of the activity. Then as an individual practice activity, I will assign a worksheet where students match bird feet and beak with food type or habitat.

B. I will review the students about the characteristics of living things back from Unit I. Then I will define adaptation, and emphasize on the kinds of adaptation. I will then give a few examples before asking the students to give their own. Then students will play the "Finding my Food Game," where students "hunt" the classmates who are acting out their food.

C. I will paste some pictures of a variety of bird beaks and bird feet around the classroom (Feet or beaks of an eagle, a duck, a maya, a woodpecker, etc.). Then I'll tell the students the rule of the game - To stand near the picture that fits the food or organism I will provide. For example, I'll say, "grasshopper!" The students will run on the picture of a beak adapted for insect-eating. After the game, students will give

the purpose of or the biological principle depicted in it. Then from this, let students derive their working definition of adaptation.

D. I will show some video clips about plant and animal adaptation. Then I'll ask the class the common theme or life characteristics depicted in the clips. I will acknowledge sensible answers before I will provide a formal definition of adaptation. I will ask students to give other examples of adaptation and provide appropriate feedback.

12. The students in Miss Lim's class have just finished an experiment on plant pigments using simple paper chromatography. After the activity, the students discussed and provided answers to several questions related to the activity. Now, Miss Lim has to wrap up the lesson. Which of the following is most similar to how you would wrap up this lesson?

A. Have the students come up with a general conclusion based on the result of their paper chromatography experiment, reminding them to use the objectives as bases for their conclusions.

B. Let the students go back to the objectives of the lesson and ask students to provide supporting evidence from the paper chromatography experiment.

C. Restate the objective for the student, then relate it to the observations they gathered from their paper chromatography experiment.

D. Have students report their conclusions based on the evidence gathered from their paper chromatography experiment.

13. Which of the following is most similar to how you would synthesize a chapter of study on the Human Circulatory System?

A. I would ask the students to recall the main concepts that they have learned in the unit, according to what they believe is important or interesting, and come up with a concept map or idea diagram that will interrelate these concepts.

B. I would conduct a unit review in the form of a "game show." Here, I would ask for some identification or true-false questions. I'll make sure that all the objectives are addressed in the game show.

C. I would restate the unit objectives for the students, and ask the students to say how the various concepts learned in the unit relate to these objectives.

D. I will suggest some websites or online channels that they can use to broaden their understanding of the topics covered in the chapter.

14. You were about to wrap up your lesson on anaerobic respiration when your student Mark raised an issue about his experience on a sealed carton of yogurt with

its lid bulging upwards. How would you deal with the scenario and continue your lesson?

A. I would throw back the issue to the students. I will ask them to brainstorm in small groups and explain the appearance of the bulge. To help them explain, I will remind them to revisit the main concepts they learned from the lesson. They will also be asked to research on the organism found in yogurt.

B. I would tell the class that yogurt contains living bacteria which is capable of anaerobic respiration. Then I would let the students suggest reasons why the bulge in the lid happened, basing their explanations from the discussion we have had.

C. I would tell the class that yogurt contains living bacteria which is capable of aerobic respiration. It also contains sugar. Since the yogurt is sealed, it provides an anaerobic condition that is suitable for alcoholic fermentation, producing carbon dioxide that uses the bulge.

D. I would ask the class a series of questions that will lead them to analyze and explain the appearance of the bulge: What are the components of yogurt? What condition is set when a box is sealed? What substances are produced when these components and this condition is met? Which of these products could have caused the bulge?

15. Mrs. Cruz is teaching her 7th graders about leaf structure diversity. She wants her students to learn about the different types of leaf margins. She begins her lesson by enumerating and describing each type of leaf margins. She then shows mounted samples of each type. After that, she asked the class to go to the school garden and collect a sample for each type of leaf margin. As an output, she asks the class to trace or sketch each leaf and label each according to the margin type. Thinking about how you would teach, which of the following best describes your evaluation of Mrs. Cruz's lesson?

A. This is a good lesson strategy because examples are provided immediately after presenting and describing each margin type. As a bonus, students are even asked to go out for them to stretch out their muscles.

B. Mrs. Cruz should have begun her lesson by allowing her students to explore the different leaves they brought to class. She should have asked them to compare the margins of their leaf samples, particularly. They should then be allowed to use the library or media center for them to identify the leaf margins. They should then be asked to mount their labeled leaf samples as output.

C. Mrs. Cruz should have begun her lesson by showing her students a video of a lecture on plant leaf margin diversity. Since there are simulations and video games available online, she should provide opportunities for students to use these simulations for them to enjoy and learn at the same time.

D. Mrs. Cruz's strategy is good. However, having students go out to collect leaf samples does not offer a higher curricular significance than letting them accomplish a worksheet on labeling the types of leaf margins in illustrated leaf samples.

Appendix J

Modified Reformed Teaching Observation Protocol (mRTOP) by Sawada, Sawada, Falconer, Turley, Belford, & Bloom. 2002)

Dear Cooperating Teachers:

1) For each item on the following lists, kindly rate your science student teacher in each characteristic on a scale of 0 to 4:

- A "0" should be used if the characteristic and its description is *not* an accurate way to describe your student teacher or his/her teaching.
- A "2" should be used if the characteristic and its description is an accurate way to describe your student teacher or his/her teaching *some* of the time.
- A "4" should be used if the characteristic and its description is a very accurate way to describe your student teacher or his/her teaching on a *regular* basis.
- Use the "1" and "3" as 'in-between' ratings if you cannot decide between the "0", "2", or "4" ratings on a particular characteristic.

Begin Here:	Please encircle one				
1. My student teacher (ST) uses teaching procedures or activities that show respect for students' prior (previous) knowledge. This prior knowledge could be wrong and needs to be corrected.	0	1	2	3	4
2. My ST designs strategies and activities that allow students to use their prior knowledge to explain or predict phenomena.	0	1	2	3	4
3. My ST provides opportunities for students to explore first (do an activity) before he/she provides a formal presentation (lecture or demonstration, etc.)	0	1	2	3	4
4. My ST can modify his/her lesson, depending on the ideas or questions originating from students.	0	1	2	3	4
5. My ST can modify his/her lesson based on the results of students' answers to her formative assessments (checks for understanding, quick questions, etc.)	0	1	2	3	4
6. My ST asks questions or problems that encourage students to use different ways to investigate or solve a problem.	0	1	2	3	4
7. My ST can design lessons that engage students as members of a "learning community." Here, classmates can give constructive criticisms or challenge the ideas of others.	0	1	2	3	4
8. When teaching, my ST focuses on the fundamental concepts of the subject. There are always some significant scientific or mathematical ideas at the heart of his/her lesson.	0	1	2	3	4

9. My ST inter-relates present lessons with past or future lessons or relates present lessons with other subjects.	0	1	2	3	4
10. My ST sees quickly what students are trying to say, and how these thoughts connect with science concepts	0	1	2	3	4
11. My ST helps and encourages students to follow general guidelines, laws, or theories to develop a solution or a model.	0	1	2	3	4
12. My ST uses many different real-world examples as teaching tools to help students understand basic science concepts.	0	1	2	3	4
13. My ST requires students to use a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, etc.) to represent their knowledge/understanding	0	1	2	3	4
14. My ST allows the students to make predictions and/or hypotheses, and encourage them to devise means to test and then validate or reject these predictions/hypotheses.	0	1	2	3	4
15. My ST engages students in thought-provoking activities that often involve the critical assessment of what they are doing.	0	1	2	3	4
16. My ST requires students to be reflective about their learning. Student reflections could start with questions like, "What made it difficult for me to understand this?", etc.	0	1	2	3	4
17. My ST uses a range of assessment strategies that measure the depth of student understanding and the application thereof.	0	1	2	3	4
18. My ST requires students to communicate their ideas to others using a variety of means and media (Making presentations, brainstorming, critiquing, listening, making videos, group work, etc.)	0	1	2	3	4
19. My ST implements a lesson or activity where there is a high proportion of student talk (student discussion), and a significant amount of it occurs between and among students.	0	1	2	3	4
20. In my ST's class, there is a climate of respect for what each student has to say. (Students express their ideas and opinions without fear of censure or ridicule).	0	1	2	3	4
22. My ST is generally approachable and encouraging to students, both in and out of class	0	1	2	3	4
23. My ST can guide his/her students to construct their understandings.	0	1	2	3	4
24. My ST is approachable and encouraging. Students can come to him/her for clarification.	0	1	2	3	4

Appendix K

Modified Inquiry-based Teaching Self-assessment Inventory (mITSAI) for PSBTs

Dear Respondents,

1) For each item on the following lists, kindly rate your science teaching during your teaching internship in each characteristic on a scale of 0 to 4:

- A "0" should be used if the characteristic and its description is *not* an accurate way to describe your student teacher or his/her teaching.
- A "2" should be used if the characteristic and its description is an accurate way to describe your student teacher or his/her teaching *some* of the time.
- A "4" should be used if the characteristic and its description is a very accurate way to describe your student teacher or his/her teaching on a *regular* basis.
- Use the "1" and "3" as 'in-between' ratings if you cannot decide between the "0", "2", or "4" ratings on a particular characteristic.

	Please encircle				
1. I used teaching procedures or activities that showed respect for students' prior (previous) knowledge. This prior knowledge could be wrong and needs to be corrected.	0	1	2	3	4
2. I planned strategies and activities that allowed students to use their prior knowledge to explain or predict	0	1	2	3	4
3. I provided opportunities for students to **explore first** (do phenomena.	0	1	2	3	4
4. I was able to modify my lesson, depending on the ideas or questions originating from students.	0	1	2	3	4
5. I was able to modify my lesson based on the results of students' answers to my formative assessments (checks for understanding, quick questions, etc.)	0	1	2	3	4
6. I asked questions or problems that encouraged students to use different ways to investigate or solve a problem.	0	1	2	3	4
7. I was able to design lessons that engage students as members of a "learning community." Here, I allowed students to give constructive criticisms or challenge the ideas of others.	0	1	2	3	4
8. When teaching, I focused on the fundamental concepts of the subject. There were always some significant scientific or mathematical ideas at the heart of my lesson.	0	1	2	3	4
9. I interrelated present lessons with past or future lessons or related present lessons with other subjects.	0	1	2	3	4
10. I was able to see quickly what students are trying to say, and how these thoughts connect with science concepts	0	1	2	3	4

11. I helped and encouraged students to follow general guidelines, laws, or theories for them to develop a solution or a model.	0	1	2	3	4
12. I used many different real-world examples as teaching tools to help students understand basic science concepts.	0	1	2	3	4
13. I required students to use a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, etc.) to represent their knowledge/understanding	0	1	2	3	4
14. I allowed the students to make predictions and/or hypotheses, and encourage them to devise means to test and then validate or reject these predictions/hypotheses.	0	1	2	3	4
15. I engaged the students in thought-provoking activities that often involve the critical assessment of what they are doing.	0	1	2	3	4
16. I required the students to be reflective about their learning. Student reflections started with questions like, "What made it difficult for me to understand this?", etc.	0	1	2	3	4
17. I used a range of assessment strategies that measured the depth of student understanding and the application thereof.	0	1	2	3	4
18. I required students to communicate their ideas to others using a variety of means and media (Making presentations, brainstorming, critiquing, listening, making videos, group work, etc.)	0	1	2	3	4
19. I implemented lessons or activities where there is a high proportion of student talk (student discussion), and a significant amount of it occurs between and among students.	0	1	2	3	4
20. My classes were dominated by a climate of respect for what each student has to say. (Students expressed their ideas and opinions without fear of censure or ridicule).	0	1	2	3	4
22. I was generally approachable and encouraging to students, both in and out of class	0	1	2	3	4
23. I was able to guide his/her students to construct their understandings.	0	1	2	3	4
24. I was approachable and encouraging. Students can come to me for clarification.					

Appendix L

PSBTs' IBSI Background and Experiences Interview Schedule

1. What do you know or understand about inquiry-based science instruction? Please write your answers below.

2. As a student, what is your best experience with inquiry-based instruction? Please describe your experiences below.

3. What do you like about inquiry-based teaching and learning? What do you not like about it?

4. How do you assess your background, exposure, or experiences with inquiry-based science instruction during your high school, college, and field study? Is it sufficient, limited, extensive, lacking?

a. High school science courses:

b. College science courses:

c. Field study and teaching internship observation:

5. How would you describe your science teachers' general approach to teaching science? (You may describe his/her general approach as teacher-centered, student-centered, rigid, structured, easy-going, democratic, laissez-faire, etc.)

a. High school science courses:

b. College science courses:

c. Field study and teaching internship observation:

d. Cooperating Teacher:

6. What challenges and successes did you observe in your Cooperating Teacher's use of Inquiry-based learning approaches?

Challenges	Successes

7. How often did your CT use inquiry methods? (As often as necessary, occasionally, sometimes, seldom, never)

8. Did your CT allow you to use what teaching strategy is best to teach a lesson or dictates on how you execute your lesson?

9. Are you ready for inquiry-based teaching and learning? Why or why not?

10. On the scale of 1 to 5, with five being the highest and one the lowest, how do you assess your readiness to apply inquiry-based learning in your future classes?

Appendix M

Inter-correlation results of the various IBSI variables

		ToE	Und	Att	AllTCP	AllLCP	SE	Pre	ToAp
ToE	Pearson Correlation	1	-.115	.061	.056	.002	.021	-.103	.017
	Sig. (2-tailed)		.358	.625	.657	.986	.867	.410	.894
	N	66	66	66	66	66	66	66	66
Und	Pearson Correlation	-.115	1	.137	-.165	.341**	.139	.309*	.198
	Sig. (2-tailed)	.358		.272	.186	.005	.267	.011	.110
	N	66	66	66	66	66	66	66	66
Att	Pearson Correlation	.061	.137	1	.254*	.311*	.197	.095	.299*
	Sig. (2-tailed)	.625	.272		.039	.011	.112	.450	.015
	N	66	66	66	66	66	66	66	66
All TCP	Pearson Correlation	.056	-.165	.254*	1	.365**	.178	.032	.197
	Sig. (2-tailed)	.657	.186	.039		.003	.153	.797	.113
	N	66	66	66	66	66	66	66	66
All LCP	Pearson Correlation	.002	.341**	.311*	.365**	1	.201	.147	.389**
	Sig. (2-tailed)	.986	.005	.011	.003		.105	.240	.001
	N	66	66	66	66	66	66	66	66
SE	Pearson Correlation	.021	.139	.197	.178	.201	1	.150	.435**
	Sig. (2-tailed)	.867	.267	.112	.153	.105		.231	.000
	N	66	66	66	66	66	66	66	66
Pre	Pearson Correlation	-.103	.309*	.095	.032	.147	.150	1	.130
	Sig. (2-tailed)	.410	.011	.450	.797	.240	.231		.298
	N	66	66	66	66	66	66	66	66
To Ap	Pearson Correlation	.017	.198	.299*	.197	.389**	.435**	.130	1

Sig. (2-tailed)	.894	.110	.015	.113	.001	.000	.298	
N	66	66	66	66	66	66	66	66

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix N

Results of the linear regression analyses

A. Predictors of IBSI attitudes of PSBTs

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	162.411	1	162.411	12.936	.001[b]
	Residual	803.528	64	12.555		
	Total	965.939	65			

a. Dependent Variable: Att

b. Predictors: (Constant), Progress

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.961	4.011		2.234	.029
	Progress	.668	.186	.410	3.597	.001

a. Dependent Variable: Att

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	SocRec	-.012[b]	-.098	.922	-.012	.838
	Cons	-.092[b]	-.679	.499	-.085	.713
	AllTCP	.118[b]	.964	.339	.121	.862

a. Dependent Variable: Att

b. Predictors in the Model: (Constant), Progress

Appendix N

Results of the linear regression analyses

B. Predictors of IBSI self-efficacy of PSBTs

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5.040	1	5.040	5.821	.019[b]
	Residual	55.415	64	.866		
	Total	60.455	65			

a. Dependent Variable: SE

b. Predictors: (Constant), FSE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.491	.680		9.540	.000
	FSE	.014	.006	.289	2.413	.019

a. Dependent Variable: SE

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	ToE	-.121[b]	-.918	.362	-.115	.825
	PCE	.013[b]	.077	.939	.010	.534
	CoE	-.092[b]	-.565	.574	-.071	.542

a. Dependent Variable: SE

b. Predictors in the Model: (Constant), FSE

Appendix N

Results of the linear regression analyses

C. IBSI understanding as a predictor of IBSI predispositions of PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	54.367	1	54.367	13.518	.000[b]
	Residual	257.391	64	4.022		
	Total	311.758	65			

a. Dependent Variable: Pre

b. Predictors: (Constant), LPUnd

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.035	.292		30.974	.000
	LPUnd	.226	.061	.418	3.677	.000

a. Dependent Variable: Pre

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	LBUnd	.078[b]	.572	.569	.072	.699
	LEUnd	-.040[b]	-.295	.769	-.037	.728
	Und	-.191[b]	-.858	.394	-.107	.260

a. Dependent Variable: Pre

b. Predictors in the Model: (Constant), LPUnd

Appendix N

Results of the linear regression analysis

D. IBSI self-efficacy as a predictor of IBSI predispositions of PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42.944	1	42.944	10.224	.002[b]
	Residual	268.813	64	4.200		
	Total	311.758	65			

a. Dependent Variable: Pre

b. Predictors: (Constant), CCSE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.384	.350		29.635	.000
	CCSE	-.080	.025	-.371	-3.198	.002

a. Dependent Variable: Pre

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	SE	.056[b]	.459	.648	.058	.931
	LPISE	.030[b]	.259	.796	.033	.992
	CKSE	.029[b]	.249	.804	.031	1.000

a. Dependent Variable: Pre

b. Predictors in the Model: (Constant), CCSE

Appendix N

Results of the linear regression analysis

E. IBSI exposure as predictors of IBSI applications by PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	423.761	1	423.761	6.688	.012[b]
	Residual	4055.303	64	63.364		
	Total	4479.064	65			

a. Dependent Variable: ToAp

b. Predictors: (Constant), FSE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	53.610	5.820		9.211	.000
	FSE	.126	.049	.308	2.586	.012

a. Dependent Variable: ToAp

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	PCE	-.215[b]	-1.328	.189	-.165	.534
	CoE	-.125[b]	-.774	.442	-.097	.542
	ToE	-.136[b]	-1.037	.304	-.130	.825

a. Dependent Variable: ToAp

b. Predictors in the Model: (Constant), FSE

Appendix N

Results of the linear regression analysis

E. IBSI understanding as predictors of IBSI applications by PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	434.685	1	434.685	6.879	.011[b]
	Residual	4044.380	64	63.193		
	Total	4479.064	65			

a. Dependent Variable: ToAp

b. Predictors: (Constant), LPUnd

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	66.832	1.156		57.801	.000
	LPUnd	.638	.243	.312	2.623	.011

a. Dependent Variable: ToAp

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Und	-.267[b]	-1.150	.255	-.143	.260
	LBUnd	-.062[b]	-.434	.666	-.055	.699
	LEUnd	-.106[b]	-.762	.449	-.096	.728

a. Dependent Variable: ToAp

b. Predictors in the Model: (Constant), LPUnd

Appendix N

Results of the linear regression analysis

F. IBSI attitude as predictors of IBSI applications by PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	400.604	1	400.604	6.286	.015[b]
	Residual	4078.460	64	63.726		
	Total	4479.064	65			

a. Dependent Variable: ToAp

b. Predictors: (Constant), Att

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	53.440	6.066		8.810	.000
	Att	.644	.257	.299	2.507	.015

a. Dependent Variable: ToAp

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	IntAtt	.045[b]	.240	.811	.030	.414
	LikeAtt	.029[b]	.154	.878	.019	.402
	UseAtt	-.073[b]	-.438	.663	-.055	.515

a. Dependent Variable: ToAp

b. Predictors in the Model: (Constant), Att

Appendix N

Results of the step-wise regression analysis

G. Learner-centered views as predictors of IBSI applications by PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	753.893	1	753.893	12.952	.001[b]
	Residual	3725.172	64	58.206		
	Total	4479.064	65			

a. Dependent Variable: ToAp

b. Predictors: (Constant), Progress

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37.548	8.637		4.347	.000
	Progress	1.438	.400	.410	3.599	.001

a. Dependent Variable: ToAp

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	LeCen	-.007[b]	-.054	.957	-.007	.894
	SocRe	.021[b]	.169	.866	.021	.838
	c	.134[b]	.991	.325	.124	.713
	Cons	.155[b]	.755	.453	.095	.311
	AllLCP					

a. Dependent Variable: ToAp

b. Predictors in the Model: (Constant), Progress

Appendix N

Results of the step-wise regression analysis

H. Learner-centered views as predictors of IBSI applications by PSBTs

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	847.723	1	847.723	14.941	.000[b]
	Residual	3631.341	64	56.740		
	Total	4479.064	65			

a. Dependent Variable: ToAp

b. Predictors: (Constant), SE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	38.081	7.911		4.814	.000
	SE	3.745	.969	.435	3.865	.000

a. Dependent Variable: ToAp

Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	LPISE	.125[b]	1.109	.272	.138	.990
	CKSE	.053[b]	.464	.644	.058	.986
	CCSE	.065[b]	.558	.579	.070	.931

a. Dependent Variable: ToAp

b. Predictors in the Model: (Constant), SE

Appendix O

Result of the Shapiro-Wilk Test for Normality of Data (Using Statistics Kingdom)

Data	*p*-value	W value	Crit value range
IBSI Exposure along LPI	0.08821	0.934311	0.9242 : 1.0000
IBSI Exposure along Content knowledge	0.45579	0.971081	0.9398 : 1.0000
IBSI Exposure along Classroom culture	0.43225	0.963038	0.9242 : 1.0000
IBSI Exposure during pre-college	0.74048	0.97696	0.9303 : 1.0000
IBSI Exposure during College	0.48303	0.967884	0.9303 : 1.0000
IBSI Exposure along Field study	0.3762	0.963353	0.9303 : 1.0000
IBSI Expo along LPI during pre-college	0.05591	0.834662	0.8299 : 1.0000
IBSI Expo along LPI during college	0.31804	0.907857	0.8299 : 1.0000
IBSI Expo along LPI during Field Study	0.30955	0.906695	0.8299 : 1.0000
IBSI Expo along CK during Pre-college	0.91161	0.970077	0.8608 : 1.0000
IBSI Expo along CK during College	0.53925	0.943101	0.8608 : 1.0000
IBSI Expo along CK during Field study	0.94464	0.973602	0.8608 : 1.0000
IBSI Expo along CC during Pre-college	0.78313	0.952253	0.8299 : 1.0000
IBSI Expo along CC during College	0.28098	0.902563	0.8299 : 1.0000
IBSI Expo along CC during Field study	0.91196	0.964573	0.8299 : 1.0000
IBSI understanding at lesson beginning	0.18914	0.85264	0.7777 : 1.0000
IBSI Understanding at lesson proper	0.99588	0.979496	0.7987 : 1.0000
IBSI Understanding at lesson ending	0.75329	0.921728	0.7149 : 1.0000

IBSI Attitude along interest	0.10529	0.798857	0.7508 : 1.0000
IBSI Attitude along liking	0.37031	0.862468	0.7149 : 1.0000
IBSI Attitude along perceived usefulness	0.99993	0.987355	0.7508 : 1.0000
IBSI Self-efficacy along LPI	0.989834	0.97727	0.8158 : 1.0000
IBSI Self-efficacy along CC	0.93434	0.967351	0.8299 : 1.0000
IBSI Self-efficacy along CC	0.8887	0.956245	0.7987 : 1.0000
IBSI Predisposition at lesson beginning	0.62665	0.904324	0.7149 : 1.0000
IBSI Predisposition at lesson proper	0.99474	0.978554	0.7987 : 1.0000
IBSI Predisposition at lesson ending	0.79611	0.927695	0.7149 : 1.0000
Overall IBSI Application along LPI	0.39441	0.903354	0.7987 : 1.0000
Overall IBSI Application along CK	0.7992	0.956465	0.8417 : 1.0000
Overall IBSI Application along CC	0.65028	0.92553	0.7777 : 1.0000
mITSAI applicationalong LPI	0.992	0.976778	0.7987 : 1.0000
mITSAI application along CK	0.86680	0.96221	0.8417 : 1.0000
mITSAI application along CC	0.70974	0.93192	0.7777 : 1.0000
mRTOP application along LPI	0.672633	0.933969	0.7987 : 1.0000
mRTOP application along CK	0.88662	0.964079	0.8417 : 1.0000
mRTOP application along CC	0.697283	0.930593	0.7777 : 1.0000

Interpretations:

Since p-value > α, we accept the H_0. It is assumed that the data is normally distributed. In other words, the difference between the data sample and the normal distribution is not big enough to be statistically significant

Appendix P
Result of the Levene's Test for Equality of Variances (Using Statistics Kingdom)

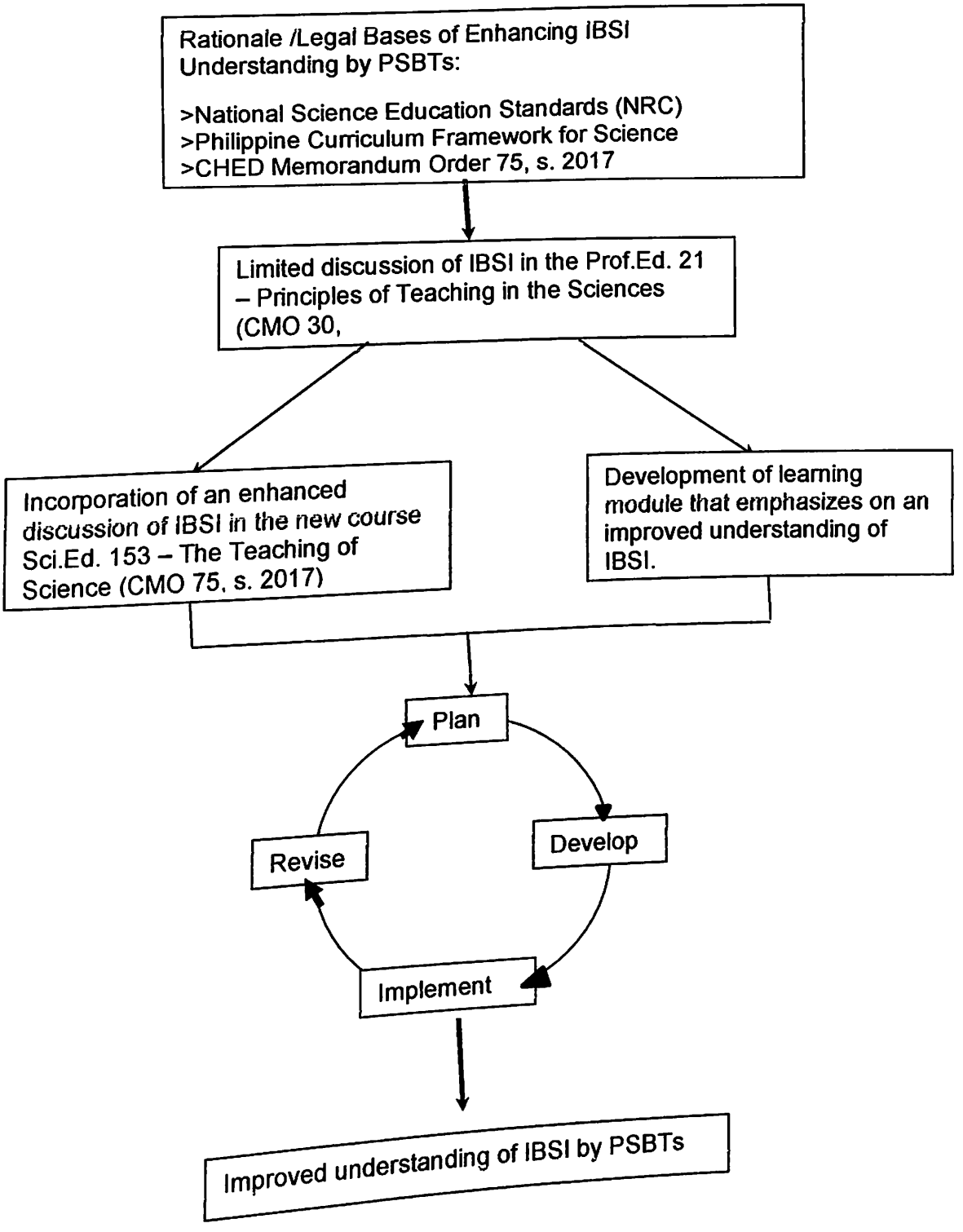
Data	*p*-value	F stat	Crit value range
Overall exposure along LPI, CK, and CC	0.97659	0.023713	-∞ : 3.3541
overall exposure during PC, C, and FS	0.97576	0.024547	-∞ : 3.1013
IBSI Expo along LPI during PC, C, and FS	0.65004	0.438552	-∞ : 3.4028
IBSI Expo along CK during PC, C and FS	0.73337	0.313038	-∞ : 3.2849
IBSI along CC during PC, C, and FS	0.471494	0.775903	-∞ : 3.4028
IBSI Understanding along lesson stages	0.404753	0.965512	-∞ : 3.7389
IBSI attitudes along the three dimensions	0.63913	0.466363	-∞ : 3.9823
Learner-centered views	0.84283	0.171139	-∞ : 3.0422
IBSI Self-Efficacy along the IBSI elements	0.11735	2.376835	-∞ : 3.4668
IBSI application along the IBSI elements	0.198707,	1.753812	-∞ : 3.4928
mITSAI appli along the IBSI elements	0.081472 1	2.849881	-∞ : 3.4928
mRTOP appli along the IBSI elements	0.16637	1.964466	-∞ : 3.4928
mITSAI vs. Mrtop	0.567915	0.331149	-∞ : 4.0617

Interpretations

Since all p-values > α, H_0 is accepted. The averages of all groups are considered equal. The difference between the variances of any pair in all the groups is not big enough to be statistically significant.

Appendix Q

Curriculum Framework on the Enhancement of IBSI Understanding by Pre-Service Biology Teachers



APPENDIX R

Scope and Sequence for Enhancing Inquiry-Based Science Instruction (IBSI) Understanding of Pre-service Biology Teachers (PSBTs)

(Bansiong, 2020)

WEEK	TOPIC OF DISCUSSION	OBJECTIVES	STRATEGIES/ ACTIVITIES	REFERENCES
1	Pretest of IBSI understanding	1. To determine the PSBTs' initial knowledge and understanding of IBSI.		Pedagogy of Science Testing Test Version 1 (POSST - 1) by Cobern et al., 2014.
1	The Need to improve the IBSI understanding of PSBTs	1. The PSBTs will explain the need for them to develop IBSI understanding.	Document analysis a. National Science Education Standards (NSES); b. Philippine curriculum framework for Science (PCFS)	1. NSES document, 2. PCFS 3. Elementary Science Methods (6th Ed.) by Martin. 2012.
1	Building IBSI Understanding	1. The PSBTs will define IBSI as a unique teaching approach. 2. PSBTs will distinguish between IBSI and other teaching approaches.	1. Using a T-chart for the PSBTs to characterize what inquiry is and what it is not. 2. Journal article study	Teaching High School Science Through Inquiry and Argumentation (2nd Ed.) by Llewellyn, 2013.
2	Choosing to use inquiry-based teaching	1. The PSBTs will analyze myths and misconceptions about inquiry-based teaching. 2. The PSBTs will explain the steps in becoming	1. Small and large group discussions on the myths and misconceptions about inquiry-based teaching; 2. Self-reflection and drawing ones "Instructional pie."	Teaching High School Science Through Inquiry and Argumentation (2nd Ed.) by Llewellyn, 2013.

		an inquiry-based teacher.		
2	Developing a philosophy of inquiry	1. The PSBTs will articulate their beliefs about teaching and learning. 2. The PSBTs will compare constructivist and traditionalist views about teaching and learning.	1. Educational philosophy or vision statement development 2. Accomplishing the Conceptions and Teaching and Learning Questionnaire 3. Case analyses, Interviewing in-service science teachers	1. Teaching High School Science Through Inquiry and Argumentation (2nd Ed.) by Llewellyn, 2013. 2. Conceptions and Teaching and Learning Questionnaire (Chan, 2001).
3	Levels of science inquiry	1. The PSBTs will distinguish among the levels of inquiry, as proposed by Banchi & Bell (2008).	1. Laboratory manual analysis as to the level of inquiry of the experiments/ activities 2. Comparing the level of inquiry in local and foreign laboratory manuals	1. The Many Levels of Inquiry (Banchi, & Bell, 2008). 2. Analysis of the level of inquiry in the laboratory (Buck, Bretz, & Towns, 2008).
3	Modifying a laboratory activity into an inquiry-based investigation	1. The PSBTs will modify a traditional "cookbook" laboratory activity into an inquiry-based investigation.	1. Activity on revising a traditional "cookbook" laboratory into an inquiry-based investigation 2. Analyzing laboratory activities as either traditional or inquiry-oriented.	1. Teaching High School Science Through Inquiry and Argumentation (2nd Ed.) by Llewellyn, 2013.
4	Planning and implementing an inquiry-based science lesson	1. The PSBTs will plan and implement an inquiry-based lesson. 2. The PSBTs will analyze and critique an inquiry-based. 3. The PSBTs will revise their lesson based on	1. Lesson planning 2. Lesson plan analysis following the lesson study framework. 3. Revising the lesson plan and reteaching.	1. Lesson study publications of UP NISMED

		the recommendations of the lesson study groups.		
5	Managing the inquiry classroom	1. The PSBTs will identify and respond to the challenges of IBSI. 2. The PSBTs will express the willingness to apply the tips in implementing and managing the inquiry classroom.	1. Journal article analysis (College Science Teachers Views of Inquiry by Brown et al., 2006) 2. Reflective journal entry (Problem-solution analysis chart)	1. Teaching High School Science Through Inquiry and Argumentation (2nd Ed.) by Llewellyn, 2013. 2. College Science Teachers Views of Inquiry (Brown et al., 2006)
5	Creating a classroom culture of inquiry	1. The PSBTs will explore the essential elements in creating, cultivating, and nurturing a culture of creativity and curiosity in the high school science classroom.	1. Science classroom and science class observation using the "Environment of an Inquiry-Based Classroom Observation Protocol" and "Students in an Inquiry-Based Classroom Observation Protocol" both by Llewellyn, 2013) 2. Accomplishing the McGill Enactment of Inquiry Questionnaire-Self-Efficacy-Teachers (MEIQ-SET, Chichekian, Shore & Tabatabai, 2016)	1. McGill Enactment of Inquiry Questionnaire-Self-Efficacy-Teachers (MEIQ-SET, Chichekian, Shore & Tabatabai, 2016) 2. Teaching High School Science Through Inquiry and Argumentation (2nd Ed.) by Llewellyn, 2013.
5	Post-test	1. To assess the changes in the PSBTs' knowledge and understanding of IBSI.		Pedagogy of Science Testing Test Version 2 to 4 (POSST – 2-4)

				by Cobern et al., 2014.

Appendix S

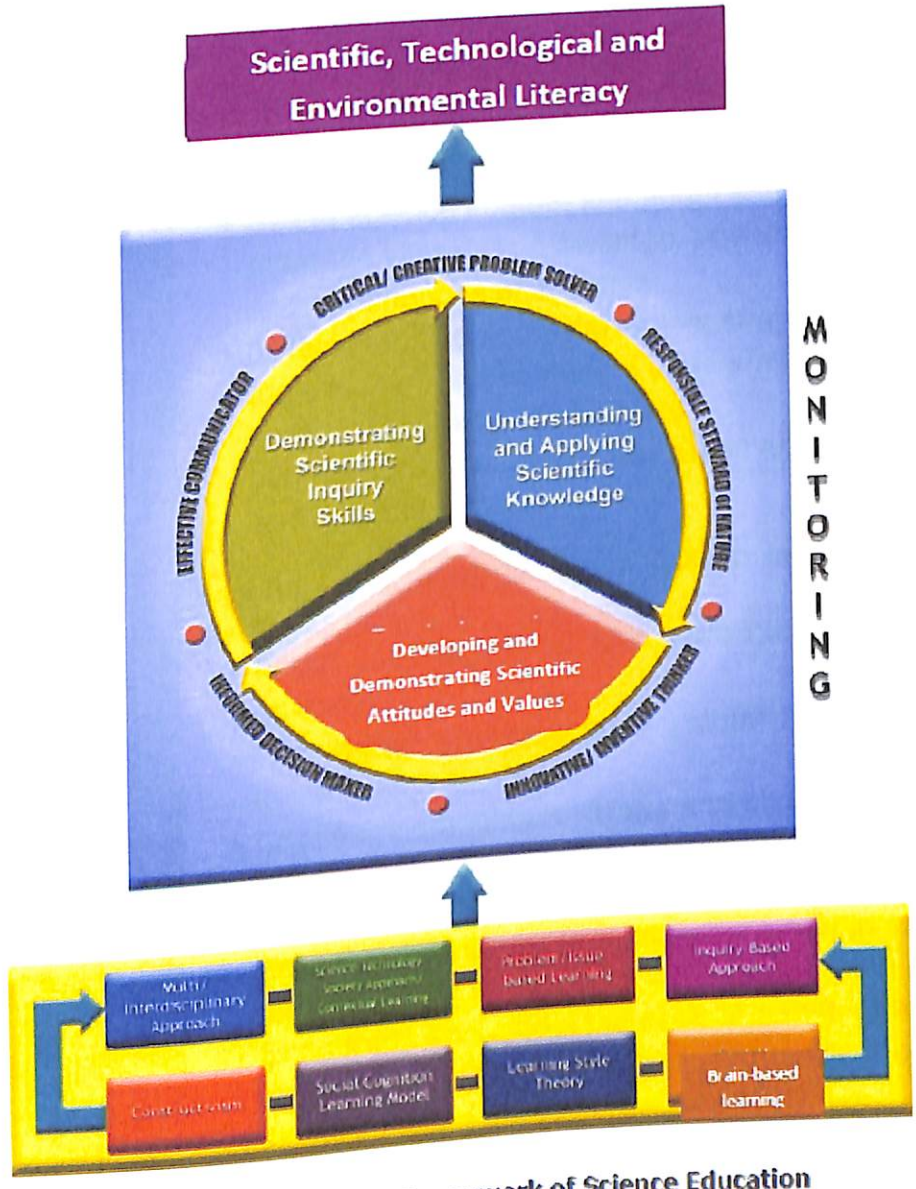
Program Outcomes Specific for Bachelor of Secondary Education Major in Science as per CMO No. 75, s. 2017

D. BACHELOR OF SECONDARY EDUCATION MAJOR IN SCIENCE

Program Outcomes	Performance Indicators
a. Demonstrate deep understanding of scientific concepts and principles.	• Display basic and comprehensive understanding of knowledge, principles of the subject matter in the sciences.
b. Apply scientific inquiry in teaching and learning	• Apply the scientific principles in solving current problems. • Uses scientific inquiry in understanding and explaining natural phenomena.
c. Utilize effective science teaching and assessment methods	• Design and utilizes appropriate instructional materials in science. • Employ effective teaching techniques for diverse types of learners in varied learning conditions • Design and utilizes a variety of appropriate assessment techniques to monitor and evaluate learning • Provide regular feedback to students
d. Manifest meaningful and comprehensive pedagogical content knowledge (PCK) of the sciences.	• Utilize appropriate pedagogy and use of technology for the different science content areas. • Demonstrate skills in various methods of teaching-learning in the sciences to include conducting science investigations, making models and prototype, and doing science research. • Create and utilize learning experiences in the classrooms to develop learner's skills in discovery learning, problem learning and critical thinking.

Appendix T

Philippine Curriculum Framework for Science under the K-12 Program



The Conceptual Framework of Science Education

Appendix U

Teaching Standards for Science by the National Science Education Standards

TEACHING STANDARD A:	Teachers of science plan an inquiry-based science program for their students. In doing this, teachers: ▪ Develop a framework of yearlong and short-term goals for students. ▪ Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students. ▪ Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners. ▪ Work together as colleagues within and across disciplines and grade levels.
TEACHING STANDARD B:	Teachers of science guide and facilitate learning. In doing this, teachers: ▪ Focus and support inquiries while interacting with students. ▪ Orchestrate discourse among students about scientific ideas. ▪ Challenge students to accept and share responsibility for their learning. ▪ Recognize and respond to student diversity and encourage all students to participate fully in science learning. ▪ Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.
TEACHING STANDARD C:	Teachers of science engage in an ongoing assessment of their teaching and student learning. In doing this, teachers: ▪ Use multiple methods and systematically gather data about student understanding and ability. ▪ Analyze assessment data to guide teaching. ▪ Guide students in self-assessment.

	▪ Use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice. ▪ Use student data, observations of teaching, and interactions with colleagues to report student achievement and opportunities to learn to students, teachers, parents, policymakers, and the general public.
TEACHING STANDARD D:	Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers: ▪ Structure the time available so that students can engage in extended investigations. ▪ Create a setting for student work that is flexible and supportive of science inquiry. ▪ Ensure a safe working environment. ▪ Make the available science tools, materials, media, and technological resources accessible to students. ▪ Identify and use resources outside the school. ▪ Engage students in designing the learning environment.
TEACHING STANDARD E:	Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. In doing this, teachers: ▪ Display and demand respect for the diverse ideas, skills, and experiences of all students. ▪ Enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community. ▪ Nurture collaboration among students. ▪ Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse. ▪ Model and emphasize the skills, attitudes, and values of scientific inquiry.
TEACHING STANDARD F:	Teachers of science actively participate in the ongoing planning and development of the school science program. In doing this, teachers: ▪ Plan and develop the school science program. ▪ Participate in decisions concerning the allocation of time and other resources to the science program.

	▪ Participate fully in planning and implementing professional growth and development strategies for themselves and their colleagues.

Appendix V

TRAINING DESIGN ON THE USE OF INQUIRY-BASED SCIENCE INSTRUCTION FOR COOPERATING AND DEMONSTRATION TEACHERS

Title: Training-Workshop on the use of Inquiry-based Science Instruction

Participants: Cooperating teachers and demonstration teachers in Science from the division of Baguio City and Benguet

Date: To be arranged

Venue: Benguet State University – College of Teacher Education Function Hall

Rationale: The curriculum framework for Science in the K-12 program of the Philippine Department of Education aspires that every Filipino learner must acquire scientific literacy. Scientific literacy can only be attained with the use of more learner-centered and context-based teaching approaches. Among the teaching approaches explicitly identified in the framework are problem-based learning and inquiry-based instruction.

To comply with the national mandate on the use of learner-centered teaching approaches such as inquiry-based learning, both in-service and pre-service science teachers must be adept at how to employ such a strategy. While the in-service science teachers may be retooled with the practices of inquiry-based instruction through in-service training, their pre-service teacher counterparts must be similarly be exposed and prepared to employ the strategy. As such, these pre-service teachers must be properly acquainted with inquiry-based teaching, both in their science and science education courses.

In a study on inquiry-based instruction and biology teacher preparation, the author found that the pre-service biology teachers' application of inquiry-based instruction during teaching internship was dependent on their exposure to such a strategy during their classroom observation and field study experiences. In other words, it appears that their main models or influences in their use of inquiry learning during teaching internship were neither by their pre-college science teachers nor their college science professors, but mainly their cooperating teachers. The aspiring science teachers who were able to observe inquiry-based instruction from their cooperating teachers were the ones who were able to manifest inquiry practices

when they taught. Moreover, the results revealed that the PSBTs' IBSI exposure at field study has significantly influenced their IBSI self-efficacy.

It is, therefore, important to equip all cooperating teachers in science with the skills and competencies they need to teach using inquiry-based instruction. Hence, this training is proposed.

Objectives: This training-workshop aims to:

1. reorient the cooperating science teachers on the curriculum mandates of the K-12 program;

2. reorient the cooperating science teachers with the principles and methods of inquiry-based instruction;

3. equip the participants with the skills needed to modify a traditional laboratory to an inquiry-oriented experiment;

4. equip the participants with the skills and competencies needed to design inquiry-based lessons.

Training Matrix

DAY	ACTIVITY	OBJECTIVES	STRATEGIES	OUTPUT
1	Registration and Opening Program	To orient the participants on the purpose of the activity.	1. Introductions 2. Orientations 3. Leveling off of expectations	Participants properly accounted for, acquainted with the activity purpose.
1	Knowledge Session (KS) 1: The K-12 curriculum framework for Science	To reorient the participants on the curriculum framework for science in the K-12 program.	1. Lecture with participant interaction	Participants reoriented and can state the curriculum mandates for science
1	Workshop (WS) 1: Revisiting my educational philosophies, and/or conceptions of teaching and learning	To allow the participants to revisit their educational philosophy and/or their conceptions about teaching and learning.	1. Questionnaire -Educational philosophy self-assessment inventory -Conceptions of teaching and learning questionnaire	1. Educational philosophy/teaching-learning conceptions clarified and established 2. Development of a personal credo as a science teacher
2	KS 2: Introduction to	To reorient the participants on the principles	1. Lecture with participant interaction	1. Participants re-introduced to IBI.

	Inquiry-based instruction (IBI)	and practices of IBI.		
2	WS 2: Delineating IBI from other strategies	To allow the participants to distinguish between IBI and other teaching strategies	1. Questionnaire -Pedagogy of Science teaching test	1. Participants being able to distinguish between IBI and other strategies 2. A Venn diagram, or a comparison table
2	KS 3: The levels of IBI	To orient the participants on the levels or variations on IBI	1. Lecture with interaction 2. Actual laboratory activity analysis	1. Participants being able to distinguish the different levels of IBI
3	WS 3: Classifying activities based on levels of inquiry	To guide the participants as they classify actual laboratory experiments in manuals.	1. Laboratory manual analysis as to the level of inquiry of the experiments/activities.	1. A report on their analysis on the level of inquiry in the experiments assigned to them.
3	KS 4 and WS 4: Modifying a laboratory activity into an inquiry-based investigation	To lead the participants as they transform a traditional laboratory activity to an inquiry-oriented investigation.	1. Activity on revising a traditional "cookbook" laboratory into an inquiry-based investigation 2. Analyzing laboratory activities as either traditional or inquiry-oriented.	Traditional laboratory transformed into an inquiry-based laboratory
4	WS 5: Planning an inquiry-based lesson	To guide the participants as they plan and develop an inquiry-based lesson of their choice.	Lesson plan analysis following the principles of lesson study	1. A lesson plan and its refined version, following the recommendations from the lesson study procedure
5	KS 5 and WS 6: Managing the inquiry classroom	To guide the participants as they identify and	1. Journal article analysis (College Science	1. The participants expressed willingness to apply the tips in

		respond to the challenges of IBI.	Teachers Views of Inquiry by Brown et al., 2006) 2. Problem-solution analysis	implementing and managing the inquiry classroom 2. Problem-solution analysis chart
6	KS 6 and WS 7: Creating a classroom culture of inquiry	To lead the participants as they explore the essential elements in creating, cultivating, and nurturing a culture of creativity and curiosity in the high school science classroom.	1. Demonstration and lessons analysis 2. Situational analysis	1. Reflections and personal insights
6	Completion and presentation/ demonstration of their outputs in the activity on modifying traditional labs.	To allow the participants to present or demonstrate their outputs during the training-workshop.	1. Demonstration and critique/feedback	Outputs on modifying traditional labs presented and/or demonstrated.