Collaborative professional learning through lesson study: Identifying the challenges of inquiry-based teaching

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In the Philippines, inquiry-based teaching has been promoted and implemented together with recently instigated curriculum reforms. Serious teacher professional development efforts are being used extensively to properly orient and present the benefits of inquiry-based teaching. Despite these efforts, there still exists a big gap in the effective implementation of inquiry-based teaching in the classroom. Lesson study, a professional development model which started in Japan, has increased in popularity among education specialists as they recognise its capabilities in building a sustainable, collaborative, and reflective professional development for in-service teachers. In this study, the lesson study framework was used to identify three challenges in implementing inquiry-based teaching in elementary school science education in the Philippines, namely, a lack of support, training, and availability of inquiry-based materials; an overemphasis on assessing content learning rather than learning through inquiry; and the difficulty and time consuming nature of inquiry approaches.

Introduction

In the past few years, the Philippines initiated a major curriculum reform leading to the implementation of the *Enhanced Basic Education Curriculum (K to 12)* in 2013. In science education, the new curriculum "envisions the development of scientifically, technologically, and environmentally literate and productive members of society who are critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers, and effective communicators" (Official Gazette of the Republic of the Philippines, n. d., p. 2). This is in answer to its goal of "developing scientific literate learners and make them informed and participative citizens who are able to make judgments and decisions regarding the applications of scientific knowledge that may have social, health, or environmental impacts" (Official Gazette of the Republic of the Philippines, n.d., p. 2). Therefore, various education stakeholders need to take initiatives in teacher professional development activities, in order for in-service teachers to acquire a full appreciation of the objectives of the curriculum reform, and learn new sets of pedagogical practices (Bernardo & Mendoza, 2009).

Various authors have presented the importance of continuing teacher professional development, especially during the implementation of curriculum reforms (Desforges, 1995; Fullan, 2007; Louden, 1991), so that their knowledge and skills will positively impact students' learning (Day, 1999; Hargreaves, 2000; Opfer & Pedder, 2011; Verloop, 2001). Peer coaching, collaborative teacher consultation, teacher study groups, and teacher mentoring are just few of the varied forms where teachers can work and learn together (Brownwell, Adams, Sindelar, Walderon & Vanhover (2006). These activities can facilitate the gradual transformation of teachers into professionals who acquire knowledge through the processes of social participation in a learning community, thereby becoming active

participants who learn from their actual teaching practices (Shriki & Movshovitz-Hadar, 2011).

In the Philippines, most of the implemented professional development efforts are designed to model inquiry teaching and actively engage teachers as learners rather than as information gatherers, to influence their instructional practices, and to enhance their knowledge and skills (Loucks-Horsley, Hewson, Love & Stiles, 1998). But despite these on-going teacher professional development efforts, there still exists an uncertainty about how inquiry is implemented in science classes. Researchers (Stigler & Hiebert, 1999; Yoshida, 1999) have seen lesson study as a promising school-based professional development activity which can be used in the Philippines. Thus this paper explores how lesson study, a well-structured professional development activity, can be an effective response to the challenges of inquiry-based teaching.

The first part of this paper presents an overview of lesson study, its unique features, and its effectiveness as a professional development model for teachers. This is followed by a discussion on how the author and lesson study teams comprising in-service teachers in an elementary school discovered and identified the challenges of inquiry-based teaching.

What is lesson study?

Lesson study is the direct translation for the term *jugyokenkyu*. In Japanese, the word *jugyo* means *lesson* and *kenkyu* means study or research. It is a professional development model widely used by Japanese teachers, wherein they conduct a systematic inquiry into their pedagogical practices through a close examination of their lessons (Fernandez, 2002; Saito & Atencio, 2013). In lesson study, a group composed of three to five professional teachers, usually within the same grade level, meet together regularly, and collaboratively investigate a "research lesson" designed to impact student achievement (Fernandez, Cannon & Chokshi, 2003; Puchner & Taylor, 2006; Cheung & Wong, 2014). Initially, the professional group work together to identify a curricular goal within a content area, and set goals for their students' improvement (Puchner & Taylor, 2006; Saito & Atencio, 2013).

The principles of lesson study coincide with the idea that learning is a social and situated process; and for teachers, their own classroom is the best venue for them to learn and improve their teaching practices. It follows a cyclical step which involves: 1) collaborative goal setting and planning the study lesson (Fernandez & Yoshida, 2004) 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 (PRD).

The essence of observation, post-lesson reflection and discussion is based on the idea that a single lesson has many aspects (either in its content or pedagogy) that must be given consideration to improve instruction (Sims & Walsh, 2009). Moreover, it is an opportunity

where teachers discuss the challenges they encountered during the implementation, and possible improvements to address those taken for granted routines, to eventually develop new teaching techniques (Cochran-Smith & Lytle, 2001; Saito & Atencio, 2013). It is important to note that in the entire lesson study process, the emphasis is on student learning and gathering the pieces of evidence from actual classroom interaction rather than a focus on teacher behaviour (Puchner & Taylor, 2006). The final activity is the synthesis of the teachers' professional learning (usually in a report form) which incorporates the revised research lesson to be pondered upon in subsequent research lesson implementations (Chokshi, 2002; Lewis, 2006; Stigler & Hiebert, 1999; Takahashi & Yoshida, 2004). Often, outside observers, acting as "knowledgeable others" are invited by a lesson study team to give advice as the lesson is developed, observed, and discussed during the debriefing and reflection (Sims & Walsh, 2009).

Integrating lesson study into professional development

Collaborative working towards a common goal is considered by many scholars as central to school reforms (Darling-Hammond & McLaughlin, 2011; Johnson & Bauer, 1992; Pugach & Johnson, 2002). According to Brownwell, et al., (2006), doing this helps teachers improve their instructional practices. Besides improving their professional well-being and students' learning (Louis, 2006), working collaboratively provides an opportunity where teachers improve with the help of the thought processes of their peers (Bower & Richards, 2006). Darling-Hammond and McLaughlin (2011) stressed that an effective professional development for teachers provides them with opportunities and appropriate support structures that encourage them to work critically on the continuous improvement of their pedagogical knowledge. It must be a lifelong and a dynamic process that is focused on learning and reflecting from everyday teaching experience (Maskit, 2011).

Hord (1997) proposed five characteristics of building a professional learning community which included: 1) a shared leadership where the school principal encourages the participation of the teachers in decision making; 2) a vision and shared values manifested by a commitment from the teachers towards student success; 3) a shared learning of the teachers in response to students' needs; 4) peer evaluation of the strategies utilised, and feedback as well as support, in order to improve student results for the entire school; and 5) physical and human conditions that will allow teachers to share ideas, collaborate and learn from each other. It is thus necessary that professional development efforts put teachers as the primary concern so that they are actively engaged in the process of a longitudinal and critical examination of their own teaching practices (Carpenter, Fennema & Franke, 1996; Horn & Little, 2010; Loughran, 2002; Luna, Botelho, Fontaine, French, Iverson & Matos, 2004; Morrell, 2004; Schnellert, 2011; Schnellert, Butler & Higginson, 2008).

Given the aforementioned qualities and importance of professional development, lesson study is a potential professional development model in the Philippine educational setting, especially with the newly implemented curriculum reform. Lesson study reinforces the idea of deepening the subject-matter or content knowledge of teachers, which according

to the National Science Education Standards (NSES) must be the essence of most professional development activities (NRC, 1996). Moreover, Kennedy (1998) claims that "professional development programs that focus on subject matter knowledge and on student learning of particular subject area are likely to have larger positive effects rather than programs that focus on teaching behaviours" (p. 11).

Inquiry-based teaching and learning

Teaching science is often equated to preparing students to cope with the changes and challenges of their lives (Shamsudin, Abdullah & Yaamat, 2013). In fact, the Next Generation Science Standards (NRC, 2000) stress that "science is the pursuit of explanations about the natural world, and technology is a means of accommodating human needs, intellectual curiosity, and aspirations" (p. 2). As such, science education should provide students with opportunities to reflect on how science as a subject helps promote their general understanding of society. Also, there must be more attention to how science educators collectively may sustain the eagerness of students to pursue science careers. Moreover, science as a subject should contribute to the development of the higher order critical thinking skills in a diverse population of learners.

To instil scientific literacy among students, the NSES (NRC, 2000) summarised the reasons for adopting inquiry-based teaching: (a) teachers need to utilise students' prior understandings in their teaching, as students build new knowledge from what they already know; (b) understanding science is more than knowing facts, thus students need to experience authentic scientific inquiry; and (c) in order to encourage effective learning, teachers need to guide students to engage in developmentally appropriate questions that are scientifically relevant (p. 24-33, 16-20).

Inquiry-based teaching and learning is the product of the blended theories of Piaget, Vygotsky, and Ausubel about the philosophical underpinnings of teaching and learning known as constructivism (Liang & Gabel, 2005), which emphasises the active thinking process of integrating prior knowledge with existing knowledge (Kirschner, Schweller & Clark, 2006). This is to prepare students to become sensible, intelligent, productive, and informed decision-makers on personal, social and medical issues, and other matters in their daily lives (Anderson, Holland & Palincsar, 1997).

Currently, the Philippine science education advocates the implementation of inquiry-based teaching and learning. This is to make students more engaged in their science activities and exercises, and encourage them to "learn science and learn about science" (Olson & Louks-Horsley, 2000). According to Kahn and O'Rourke (2004), through inquiry-based teaching and learning students' curiosity is awakened, thus encouraging them to actively participate, explore, seek out new knowledge, and formulate multiple solutions to a given task. This is with the ultimate goal of helping students to acquire skills in analysing, synthesising information, and applying it to solve current and future problems (Trautmann, MaKinster & Avery, 2004). Thus, various authors claim that this teaching method significantly improves students' science achievement (Lambert & Whelan, 2008)

and learning performance (Burkham, Lee & Smerdon, 1997), and enhances students' self-discovery and problem solving abilities (Laxman, 2013).

Methodology

Context of the study

The context of this study was a longitudinal, sustainable professional development program to strengthen the teachers' instructional practices through lesson study. The first phase was a five-day (40 hours) seminar-workshop which covered orientation on the nature of lesson study and inquiry-based teaching, collaborative goal setting and lesson plan development, constructive critiquing of lesson plans, and revising of lesson plans. One lesson plan was constructed by each group of teachers from Grades 1-6. The lesson plans were tried-out by the teachers in each level with the help of the experts. Based on the results of the try-out, the lesson plans were revised accordingly for the first lesson implementation. The first implementation was followed by a post-lesson reflection and discussion (PRD), with the author acting as the facilitator. Consensus was established after the PRD so that lesson plan revision may be done whenever necessary in preparation for the second lesson implementation. It is interesting to note that lesson implementation and PRDs were spread across the school year, taking one level at a time, with an interval of at most five days between the first and second implementation. During each lesson implementation, another expert was invited by the author to observe, constructively critique, and participate in the PRD.

Participants

The participants of this study were obtained from a group of 30 elementary school science teachers, from a public school, who participated in a professional development program through lesson study. They were chosen by their school head in accord with their availability during the summer break. Each level in the school was represented by five teachers constituting one lesson study team, with a total of six lesson study teams. In the course of the seminar-workshop, each lesson study team was assigned to one member of the training team who facilitated the observation and post-lesson reflection and discussion, prepared the documentation and initiated the monitoring of their activities. The author was purposively assigned to Grade levels 2, 4 and 6, and two from each of these groups of teachers became the participants in the research. These six teachers were the ones who implemented their collaboratively designed, constructively critiqued, revised, and tried-out lesson plans. There was a limitation on numbers imposed by the availability of follow-up funds for school visits, and the availability of the implementing teachers. Another limitation to the number of lesson plan implementations studied in this research occurred because oftentimes a particular lesson plan was timetabled simultaneously in more than one classroom.

Table 1: Demographics for teachers participating in this study

Grade level	Teacher	Teaching experience (Public/Private)/ Subjects taught	Years in service	Age	Gender
2	1	Public school /All	16	45	Female
	2	Public school /All	13	43	Female
3	3	Public school /All	5	28	Male
	4	Public school /All	12	43	Female
6	5	Public school /Science	9	39	Female
	6	Public school /Science	6	31	Female

Research design and data collection

This study employed a qualitative case study design to gather teachers' insights on what they are currently experiencing as challenges in implementing inquiry-based teaching. Data collection started at the beginning of the seminar-workshop. Data were obtained in various forms, including audio recordings, field notes and video recordings of the teachers' activities and interactions, from the seminar-workshop to the final lesson revision of each lesson study team that was monitored by the author. To supplement this data, a formal interview was conducted at the end of the school year. The data that were selected focused on the teachers' challenges in implementing inquiry as a teaching strategy in elementary school science education.

Data analysis and interpretation

Analysis of data took place in two phases. First, all transcripts related to challenges in implementing inquiry-based teaching were selected. Patterns were noted, coded, and categorised using the constant comparison method (Strauss & Corbin, 1990). To maximise the analysis of the patterns based from teachers' insights, five categorisation units were generated by the author. However, initial validation failed to satisfy an acceptable value for validity and reliability analyses, and therefore the analysis was narrowed into three interaction units that affirm the challenges of inquiry-based teaching, as identified by Welch, Klopfer, Aikenhead and Robinson (1981). These are listed in Table 2.

Keywords were used to categorise the teachers' insights using the *Find* tool in Microsoft *Excel*. Teachers' insights were re-grouped according to whether they belonged to one or more of the challenges of inquiry-based teaching. To establish validity on the assigned categories, the author obtained two outside researchers who re-categorised the teachers' insights. Inter-rater reliability was computed using Cohen's kappa reliability analysis and yielded an acceptable kappa value, .708. To establish a consensus on the categories, all disagreements among the raters were collaboratively identified and re-categorised by the author and the other raters.

Table 2: Interaction coding used in this study

Interaction/fragment units	Explanation of the interaction
The lack of support, training and available inquiry-based materials (IF code: TLST)	Teachers' insights were focused on either insufficiency of inquiry-based materials or inadequate training to familiarise them with inquiry-based teaching.
The overemphasis on content learning rather than learning through inquiry (IF code: TOCL)	Teachers' insights were focused on the nature of the curriculum which did not emphasise in-depth discussion in science lessons; the interaction/fragment units present teachers' insights about the advocacy on quantity rather than quality learning.
The misconceptions about, difficulty with, and the time-consuming nature of the inquiry approach (IF code: TDTC)	Teachers' insights were on their misconceptions of inquiry-based teaching (Rankin, 1999), difficulty of enacted practices of inquiry-based teaching, and the time-consuming nature of the inquiry approach.

Results

Grounding this work on building a sustainable, school-based, and reflective professional development for teachers helped various education stakeholders to identify the challenges facing successful implementation of inquiry-based teaching. The teachers' collaborative involvement in groups provided them with opportunities to reflect on their current instructional practices. This section discusses three primary challenges faced by teachers who are implementing inquiry-based teaching in their classes. Through audio recordings, field notes, video recordings, and formal interviews, teachers' insights were categorised into one or more of the challenges that emerged (Table 2).

Lack of support, training, and available inquiry-based materials

Inquiry-based teaching is one of the prescribed teaching approaches for science education in the Philippines, yet most teachers are still confused about its proper implementation. According to Eltinge and Roberts (1993) and Welch et al. (1981), in elementary school science classes, only about 15 percent of the class hours are spent upon inquiry activities. This figure seems to be matched in the Philippine science education setting.

The following statements by the teachers in this study illustrate the first challenge of implementing inquiry-based teaching:

> Teacher 1: Usually, we do not know how to implement inquiry-based teaching because of lack of training. If there are trainings, it is usually on a lecture form and not hands-on.

> Teacher 3: There are times that we really like to implement inquiry-based lesson but we lack support. We lack materials to prepare our activities. We just prepare simple materials according to our budget.
>
> Teacher 5: We have insufficient set of inquiry-based materials in teaching. What we only have are the textbooks which are not inquiry-based according to what we learned from our training.

Based on the teachers' responses, current school structures seem not to support inquiry-based teaching. With the strong accountability to teach the whole of what was included in the curriculum guides, teachers feel obliged to teach facts – information that is required for division-wide administered tests – rather than engage students in inquiry (Anderson & Helms, 2001; Barab & Luehmann, 2003; Welch et al., 1981).

The disappointing reality of implementing inquiry-based teaching can often be attributed to teachers' insufficient knowledge (Alberts, 2000; Radford, 1998). Even if inquiry is prescribed and generally accepted to be the most effective way to teach science, lack of training or intensive workshops which serve as a venue for teachers to be familiarised and become adept with it is one of the reasons for the failure of its full implementation. Teachers often find it difficult to sustain their practice even after short-term courses of capacity building related to inquiry-based teaching. In fact, effective inquiry-based teaching can only be observed when teachers are assisted by knowledgeable others through collaborative lesson planning. This supports the findings of the survey conducted by Wenning (2005) that teachers' traditional teaching habits are really hard to change after long periods of use. According to the study of Schneider, Krajcik and Blumenfeld (2005), most teachers often revert to traditional teaching practices even after experiencing inquiry-based teacher education programs. With these findings, it is all the more necessary that sufficient trainings or workshops be administered in order to gradually change the usual teaching practices of teachers.

The lack of appropriate teaching materials is another prevalent problem for the implementation of inquiry-based teaching. Most teaching materials in the Philippines were written in an expository way. As such, students often view science as accumulated facts rather than a form of investigation. According to Wenning (2005), with these kinds of resources, students find difficulties translating the science ideas contained in their textbook into an active form of inquiry. In the Philippines, most classrooms and schools are not equipped with sufficient teaching materials and do not serve as venues to engage students in hands-on or minds-on types of inquiry learning. School climate, teachers' expertise, and availability of inquiry-based materials are therefore critical in the effective implementation of inquiry-based teaching.

Overemphasis on assessing content learning rather than process learning

Learning through inquiry means that students learn with understanding of the science process skills, and the underlying scientific ideas, principles, and theories. It is a two-way process wherein teachers serve as channels that provide opportunities for active engagement and maximising students' understanding of science concepts (Wenning,

2005). Putting these principles in mind, most teachers tend to overemphasise on content and set the scale of students' knowledge acquisition by the quantity of the concepts that are introduced, rather than on the importance of a deeper sense of understanding. In this study, the Grade 2 lesson study team implemented their first and second lesson to special science classes. Even with an intention of doing more inquiry activities aligned to the cognitive abilities of the pupils, teachers cannot eradicate the traditional didactic method because of the quantity of topics they are expected to tackle.

Another challenge shared by the team was their difficulty in formulating and integrating thought-provoking questions in the learning activities that would stimulate pupils' thinking processes. Also, from the planning to the implementation stages, the teachers mentioned that their lessons were more focused on how to finish a topic rather than on pupils' understanding. According to them, because of the number of topics that needs to be covered, they have a tendency to just focus on introducing the concepts, paying less attention to understanding. This is aggravated by the issues with the delivery of assessment procedures. While standardised assessments in every grading period exist, teachers are often compelled to "teach to the test" and neglect the opportunities to develop their pupils' conceptual understanding.

Below is a teachers' statement on these matters:

> Teacher 4: We really need to finish the topics in the curriculum guide. Because of this, there are times that we do not let pupils perform activities just to cover all the topics that are needed to be discussed. They might be included in the Periodic Test. What we usually do is to lecture these topics especially after class suspensions.

There were also times when teachers prepare so many activities without concept processing. According to them, they have a notion that the more activities they ask their pupils to do, the more effective the lesson will be. Especially during their demonstration teaching, the school heads often pay attention to the quantity of pupils' activities on a certain topic. As such, there is a big tendency for the teachers not to process what transpired in the activities of the pupils. Also, they are usually asked to finish all parts of the lesson, from motivation to evaluation. This creates a complete picture of a show-and-tell scenario in most science classes. This also limits the amount of investigative activity which is supposed to be a time to enrich pupils' inquiry experiences.

> Teacher 2: We are used to ask pupils many activities to do especially during demonstration teaching because those are what the heads look for. And they need to observe the lesson from motivation to evaluation. Most of the time, we also have to work according to our budget of work. We really need to finish the lessons in the curriculum guide because those might be included in the Periodic Test.

Supervision from the school administration is another factor. Most of the school administrations are often hesitant to implement inquiry because of lack of content knowledge. Especially for smaller schools, principals often take responsibility for supervising teachers' pedagogical knowledge development. Thus, school principals who

lack science content knowledge will find difficulty in empowering teachers towards inquiry teaching.

Misconception, difficulty, and time consuming nature of inquiry approach

While various researchers claim that inquiry-based teaching fosters significant improvements in students' achievement, teachers claim that implementing inquiry-based teaching in their classroom is time-consuming. In the Philippines, a typical teacher teaches from four to six hours per day. Considering this, teachers have limited time to prepare inquiry-based lessons.

> Teacher 1: Isn't it inquiry-based when we let our pupils do activities related to the lesson? This is what I presume. For example, in high school, isn't it inquiry-based teaching when they do laboratory activities because students are allowed to explore? We also follow the scientific method which is said to be the way science should be.
>
> Teacher 3: Inquiry teaching seems to be suited only to high performing students. In our school, we only have two special science classes. Majority of our students are from low to average performing. It is difficult to let them follow instructions on their own.
>
> Teacher 4: Based on experience, teaching through inquiry takes a lot of our time; our curriculum requires us a lot of content coverage which are needed to complete the competencies.

From the teachers' insights, there is a clear picture of the existence of their misconceptions about inquiry. Teacher 3's insight supports Llewellyn's (2002) analysis of misconceptions of inquiry, finding that it is regarded as only for high achieving students. While the NRC (1996) stressed that "given the diversity of student needs, experiences and backgrounds, and the goal that all students will achieve a common set of standards, schools must support high quality, diverse, and varied opportunities to learn science" (p.221), this idea remains a misconception among teachers. If everyone is to be prepared to adapt and be knowledgeable about the present society, the more likely it becomes, that students will be taught through inquiry to develop their critical thinking.

One issue is that, oftentimes, inquiry is equated to the scientific method. The AAAS (1993) stated that doing inquiry is not restricted to following the steps of the scientific method. In as much as most science activities are presented with procedures, teachers should bear in mind that there is more to it when they are doing inquiry. These procedures must only serve as "awakening statement" in order for the students to formulate their own questions as teachers guide and mentor them in the process.

Another issue deduced from the Teacher 2's answer is that inquiry requires a lot of time to implement. While science education advocates content and process at the same time, giving enough opportunities for the students to explore the connections between their prior knowledge and new knowledge is still the most effective way to teach science. Inquiry then, facilitates students to build a scientifically-oriented sense making of the world at large. If this happens, only then does the NSES become successful in its

advocacy of engaging students in inquiry-based activities which develop their ability to critically think and interact with the society in a scientifically-oriented manner. Students should not isolate sense making from their everyday experiences and the way they do it in schools. The science concepts must be used to explain everyday phenomenon because science issues may arise and require critical thinking anytime. In fact, NSES recommends science to be taught to impart to students the accumulated knowledge of a field leading to a robust understanding of science. Thus, science teachers should help students to acquire both scientific knowledge of the world and scientific habits of mind at the same time (NRC, 2000).

Discussion

In the year-long professional development of the teachers which was documented in this study, the experts tried to build each teacher's capacities within a set of concrete activities including lecture sessions, workshops, collaborative lesson planning, classroom observations, and post-lesson reflections and discussions. These activities provided an overall picture of the extent and the need for a professional development that aims to fully implement inquiry-based teaching. The objective was to provide sustained support to teachers as they begin to realise and express their current challenges, and at the same time foster the development of learning communities where they provide instructional support to each other.

Results indicate a strong need for today's elementary school science teachers to engage in sustainable professional development, as they struggle towards the proper implementation of inquiry-based teaching. After characterising the teachers' insights, it was understood that the teachers' analyses of their instructional practices deepen as they engage continuously in collaborative and constructive self-assessment and discussions. According to Hung and Yeh (2013), with enough facilitation in collaborative learning activities, teachers are able to extend their professional knowledge, take initiatives in their own classroom implementations, and improve through constant inquiry into their instructional practices.

In the Philippines, the concept of inquiry-based teaching is not especially new to teachers. However, its proper implementation seems to be coupled with many challenges. Following the framework of lesson study as a professional development model, teachers discussed their difficulties in implementing inquiry-based teaching and learning into their classes. Faced with this reality, a call to re-define the dynamics of scientific inquiry inside the classroom is deemed necessary. Tracing back, the root of the problem is in pre-service teaching. Only when pre-service teachers are taught using inquiry, will the basic education setting be transformed into an inquiry-based one. The focus of tertiary education, especially for teachers, must be inquiry on the process aside from enriching their subject matter knowledge. Tertiary education needs fine-tuning of teacher education with increased emphasis on constructing inquiry-based materials and implementing them inside the classroom and building networks with education researchers. For in-service teachers, in-depth practice with the help of knowledgeable others should be conducted to enable a gradual change towards re-defining the ultimate goal of science education.

The study yielded three challenges for inquiry teaching that need to be addressed in pre-service education. While committed to adopt inquiry as a teaching strategy, it became clear that in-service teachers need collegial and collaborative support in implementing inquiry inside their classrooms. They became very vocal concerning whom to approach when they have questions in both content and pedagogy, and wanted opportunities to learn more on how to align inquiry to the diverse nature of pupils. As the teachers expressed themselves in the PRDs, they implicitly shared the disjunction between their theoretical knowledge gained in pre-service education, especially for the younger teachers, and the traditional practices for the older ones. The in-service teachers, however, did not demonstrate resistance to change in their current practices. Instead, they became very open in sharing their realisation of the importance of blending theoretical knowledge, constant research, and having sustainable and systematic inquiry, not only into their teaching practices but into their profession in the long run.

Conclusion

In this study, through interviews and post-lesson reflections and discussions, three barriers to inquiry teaching were identified by the team, especially from the teachers, including: 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. Through collaboration, teachers and knowledgeable others shared the problems of discovering connections between the research lesson and pupils' learning outcomes, leading to possible changes in teachers' practices (Ermeling, 2010).

The above-mentioned challenges in implementing inquiry-based instruction must not discourage education specialists and the Department of Education of the Philippines from continuing to advocate and support inquiry-based teaching and learning. However, in order to fully and effectively implement inquiry-based teaching, there must be a continuous re-defining of the ideals of science education and the educational system. This can only be achieved through training, academic support and supervision, and provision of enough support to develop inquiry-based materials.

Situated in the context of in-service public school science teachers, the present research employed lesson study as a professional development model to enhance the capacity of teachers to implement inquiry-based activities. In the course of the study, several interaction modes led the author to track the difficulties of the teachers in implementing this teaching method. Indirectly, several interactions were focused but not limited to making the teachers express their challenges encountered with inquiry teaching. Thus, this study showed the value of establishing partnerships between university experts and the teachers in the field.

This study would also like to emphasise that, as a process-oriented case study, the findings were merely representative of what these teachers really experienced within the context of the established professional learning community. Findings, however, are deemed significant in this context, as the study began to extend theoretical understandings of

changes in teachers' instructional practices, grounded on participatory, sustainable, and non-threatening environments. Thus, based on the results, this study hopes to provide a benchmark of information on how teachers are learning as they become engaged in collaborative inquiry wherein their own classrooms become an object of their learning.

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