# Development of Science Process Skills in Online Mode: A Lesson Study

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***Abstract-*** Teachers play a critical role in teaching science process skills in the classroom by organizing and coordinating learning experiences and instructing students about how to find scientific knowledge. Literature even cites the importance of teachers' science process skills in shaping lessons that promotes scientific literacy. As such, even in times of pandemic, science teachers must look for effective and efficient strategies that will help in creating a learning environment critical for student's in acquiring these science process skills, especially in the online setting. The purpose of this study is to explore how teachers use lesson study in developing online lessons that promotes science process skills through collaborative discussions in the new normal setting. Qualitative Grounded Theory approach is used to compile, interpret, and report data in this research. A total of twenty (20) teachers from different divisions of the National Capital Region (NCR) served as participants in this study. Data were yielded from online recorded lessons and observations, online post conferences and online weekly meetings of the lesson study group from August to October, 2020. As a result science teachers developed lessons that promotes science process skills in the context of online lesson study through their knowledge and skills about the online pedagogy used, instructional tools, past experiences, school's beliefs and ongoing practices. Science process skills are observed in the critical areas of the online research class namely: Teacher-student interactions, classroom activity and students' output. From the developed online research lesson, the science process skills observed are social-interaction skills, information gathering skills, analyzing, and reasoning skills and communicating skills. Through the development of the science process skills in online research lessons, science teachers obtain an understanding of the lesson study process, learn instructional and class management strategies online and develop skills and knowledge in teaching science online.

***Index Terms***- Science Process Skills, Lesson Study, Online Mode

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## I. Content and Rationale

We live in a time when scientific understanding has evolved exponentially, and technology has advanced at a fast pace. Especially now that we are in a pandemic, its implications can be seen in every aspect of our lives. Science education is important for society's potential progress. Countries around the world, especially developing countries, have been working to improve the quality of science education.

The dawn of the twenty-first century, along with these technological advancements, presented numerous challenges to various parts of the Philippine education system, especially the science education. Schools have been tasked with producing graduates who are globally successful and possess 21st-century science process skills.

As technology is a major part of learning in the twenty-first century, e-learning is vital to the education system through technology and internet connectivity, which is open to approximately 6 out of 10 of the world's 8 billion people (Aazam et al. 2014). The use of computers, smartphones, and other devices in the teaching and learning process is a measure that every school must take to remain relevant in today's world.

As COVID-19 advances, the need for providing e-learning has been stressed (Sahi, Mishra, & Singh, 2020). Online class are supported by all government agencies such as the Department of Education (DepEd) to deal with pandemic problems, school restrictions, health protocols, and social distancing practices. Schools are now looking into the possibility of online or flexible learning, which includes both online and offline courses (Narmada & Somasundaram, 2020).

Given the current ordeal of COVID-19 pandemic, this online setting / mode brought more challenges for science teachers to promote science process skills to their students.

Science process skills are observed as "learning how to learn" because children learn to learn critically and to use data creatively and continue learn when they make discriminatory observations, organize, and analyze facts and concepts, give reasons for certain outcomes, evaluate, and interpret results, make reasonable findings, and predict them (Martin et al., 2001).

Process skills define the types of thinking and reasoning that are required. Process skills are classified into two types: basic process skills and integrated process skills. Basic science process skills assist children in expanding their learning through experience in science. Children start with simple ideas and build on them to form new and complex ideas. It is hoped that focusing on science process skills will assist children in discovering meaningful information and accumulating knowledge by building their understanding within and outside of the science classroom (Martin et al., 2001)

Science process skills are described as problem-solving abilities in which a problem is represented, and a formal process is followed to arrive at a solution (Gagne et al., 1993). Science process skills are important for teaching information acquisition methods. Students need process skills both when conducting experimental investigations and when studying (Harlen, 2000; Taconis, Ferguson-Hessler & Broekkamp, 2000). Science process skills are often thought to help students improve higher order thinking skills, ensuring that they have a positive learning experience (Germann & Aram, 1996; Lee et al., 2002).

Basic science process skills, according to Germann & Aram (1996), provide the analytical foundation for scientific inquiry. The prerequisites for the integrated process skills are the basic process skills. The terminal skills for solving problems or conducting scientific experiments are the integrated method skills.

Many researchers have looked at science process skills in science education around the world. (Lazarowitz & Huppert, 1993; Germann & Aram, 1996; Harlen, 1999; Beaumont-Walters & Soyibo, 2001; Huppert,Lomask & Lazarowitz, 2002; Harrell & Bailer, 2004; Monhardt & Monhardt, 2006). Often concerned with students' acquisition and success of science process skills, as well as their links to other skills such as critical thought and achievement.

Considering that science teachers are the primary source of science education, it is unavoidable for seasoned and novice science teachers to develop lessons that promotes science process skills to its students in science class, more challenging enough in the online setting.

## I. Action Research Questions

The purpose of this study is to explore how teachers use lesson study in developing online lessons that promotes science process skills through collaborative discussions in the new normal setting It specifically sought to answer the questions: Through Lesson Study,

1. What are the different teacher-related factors that contributes to the development of online research lessons that promotes science process skills in the online setting / mode?
2. What are the critical areas in the online research lesson where science process skills are observed?
3. What are the different science process skills observed online?

## II. Proposed Innovation, Intervention and Strategy

*Online* Lesson Study

Lesson study entails groups of teachers working together on the design, implementation, testing, and improvement of one or more face to face / online research lessons (Goei, 2012).

Process:

As seen in Figure 1, actual face to face / online classroom lessons taught to students that are (a) based on a specific issue or focus of pedagogical practice created by teachers shared in meetings or similar shared online platforms, (b) meticulously planned in collaboration with one or more colleagues thru a series face to face meetings / synchronous video conferencing, (c) observed by other teachers actual or online, (d) recorded for review and reflection, and (e) discussed by members of the lesson study group, other colleagues, and knowledgeable others (Goei, 2020).

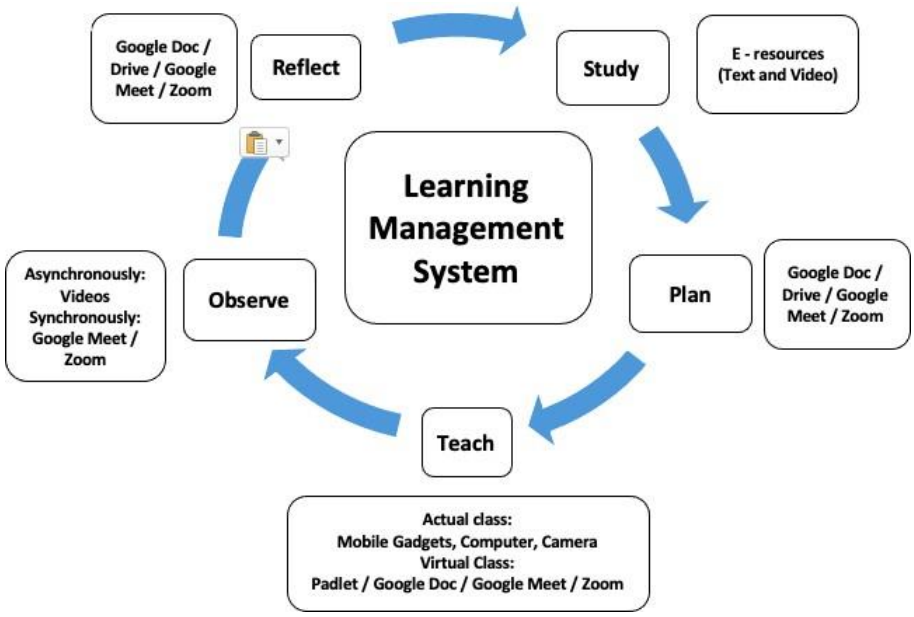


***Figure 1. Hybrid lesson study structure***

## III. Action Research Methods

### a. Participants and/ other Sources of Data

A total of 20 school personnel were involved in the lesson study group / team from selected school's division in the National Capital Region. These includes 1 principal, 1 education program supervisor, 2 public school district supervisor, 1 head teacher, 5 master teachers, 10 regular teachers. Online meetings were held via Google Meet once a week for the period of August to October 2020. Two lesson study cycles were produced involving 2 teachers per cycle that will implement the lesson study process teaching junior high school students in the Capital of the Philippines.

### b. Data Gathering Methods

In-depth understanding of the method and its relevance to teachers through their own voices and vocabulary, a qualitative design – Grounded Theory (Creswell, 1999) was chosen as the most suitable research methodology for this study. (a) Recorded online class, (b) online observational field notes / meetings (c) online post conferences discussion was used for data sources.

### c. Data Analysis Plan

As shown in Table 1, open coding, axial coding and selective Coding are the three essentials of Grounded Theory, according to Creswell (2009, p. 13) that defines grounded theory as a strategy of inquiry in which the researcher derives a general, abstract theory of a process, action or interaction grounded in the views of the participants.

| Table 1. Data Analysis Plan using Grounded Theory | |
|---|---|
| Steps in Grounded Theory | Actions Taken |
| The initial step or precoding is also called open coding, which is the action of being open to theoretical possibilities and conceptual categories (Charmaz, 2006). "Insight into particular coding categories" and "casual factors that affect the core phenomenon" are provided by open coding. (Creswell, 2007, p. 161). | The researcher transcribes all the recorded online class, online observational field notes / meetings and online post conferences discussion from the teachers (T1, T2, T3…) as members of the LS Team / Group that highlights open themes and codes to all those data sources. |
| The second step of coding, axial coding, involves "crosscutting or relating concepts to each other" (Corbin & Strauss, 1998, p. 195). It is also the process of arranging and categorizing codes to progress toward synthesis and explanation of larger data segments (Charmaz, 2006). | Guided by the research questions, the researcher then organizes and categorize these codes and themes explaining their relationship with one another. |
| Corbin & Strauss, 1998 refer to the third analytic level as "selective coding" meaning that at this point the researcher treats the various code clusters in a selective way, deciding how they relate to each other and what these codes will tell. | After organizing and categorizing those themes and codes, the researcher looks for the connection and correlation of the grouped themes and codes with one another. |
| Theoretical coding is the last step of piecing together the codes to introduce new concepts or theories about possible relationships and phenomena uncovered in the data. | |

Result and Discussion

The action research successfully provides themes (see Table 2) related to the development of science lessons that promotes science process skills thru lesson study.

| Table 2. Result Findings | |
|---|---|
| Research Question: | Themes |
| 1. What are the different teacher-related factors that contributes to the development of online research lessons that promotes science process skills in the online setting / mode? | online pedagogy instructional tools past experiences schools' beliefs ongoing practices |
| 2. What are the critical areas in the online research lesson where science process skills are observed? | teacher-student interactions classroom activity students' output |
| 3. What are the different science process skills observed online? | social-interaction skills information gathering skills analyzing and reasoning skills and communicating skills |

*What are the different teacher-related factors that contributes to the development of online research lessons that promotes science process skills in the online setting / mode?*

- *Online Pedagogy*

Online education is widely spoken of best online teaching practices, however in pedagogical literature what is coined as "best practice" differs according to the disciplinary content, education level (elementary, secondary school, tertiary school), curriculum and style of education. According to Serdyukov (2015), Online Pedagogy includes virtually all methods for improving learning experiences (including classroom instruction, interaction with technology, means for delivery of content, etc.) and highlights teaching and learning dynamics context and interactions.

Appropriate Online Pedagogy, according to Luscinski (2018), is "a method that has been regarded more effective than other alternatives due to increase positive outcome produced." After implementing two research lessons during the online lesson study, the LS group found out that the appropriate online pedagogy used for Grade10 Science (Earth and Space) in the research lesson must be problem based or online-problem based learning. A best practice or pedagogy is a technique or methodology that has been demonstrated by experience and/or research to produce the desired result" (Luscinski, 2018 p. 22).

Table 3. Sample Transcribed Interviews

| Teacher Participant | Transcribed Inputs from all recorded data sources |
|---|---|
| T3 | *"We should begin with a problem that makes our student puzzled."* |
| T6 | *"Setting the class with real-time thought-provoking problems that they easily adapt"* |
| T8 | *"Contextualized situations that students can relate and participate easily"* |
| T15 | *"Create scenarios that will test what they learn from their asynchronous class."* |

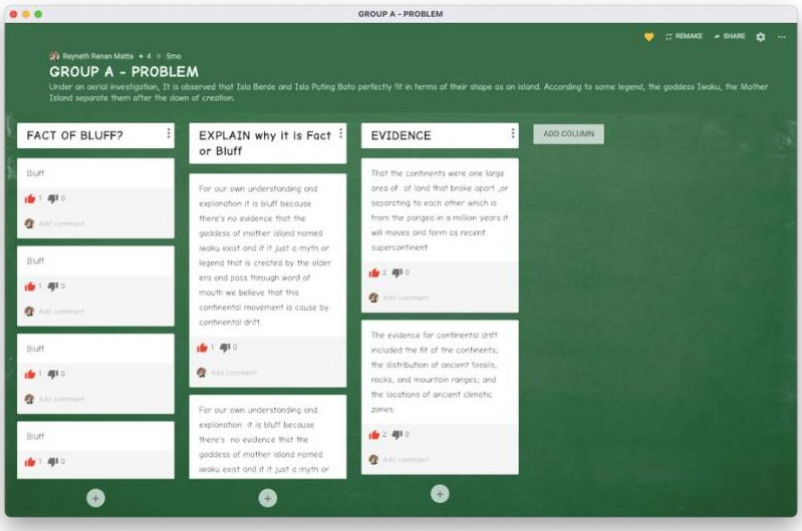


***Figure 2. Online PBL Instruction***

Table 3 shows how teachers suggest *online* Problem Based Learning. Problem-Based Learning (PBL) is a teaching approach in which students are taught concepts and values using complicated real-world problems rather than the simple presentation of facts and concepts. PBL will help students improve critical thinking skills, problem-solving abilities, and communication skills in addition to course material. It may also facilitate collaborative work, the discovery and evaluation of research materials, and lifelong learning as shown in Figure 2. (Duch et al, 2001).

- Instructional Tools

The lesson study group focuses on the use of the discussion boards to engage students in problem-based learning scenarios (Braidman et al. 2008), where online involvement is qualified (needed for engage of ideas) rather than contributory (needed as grade requirement) (see Table 4). Analyzing online class postings for the purpose of generating results necessitates the use of software applications.

| Table 4. Sample Transcribed Interviews | |
|---|---|
| Teacher Participant | Transcribed Inputs from all recorded data sources |
| T2 | *"Lessons must have platform for online discussions"* |
| T4 | *"The lesson must have strong communication between teachers and students, students and peers"* |
| T10 | *"Posted ideas of students or group of students must be present"* |
| T18 | *"Exchange must ideas must be evident and observable online"* |

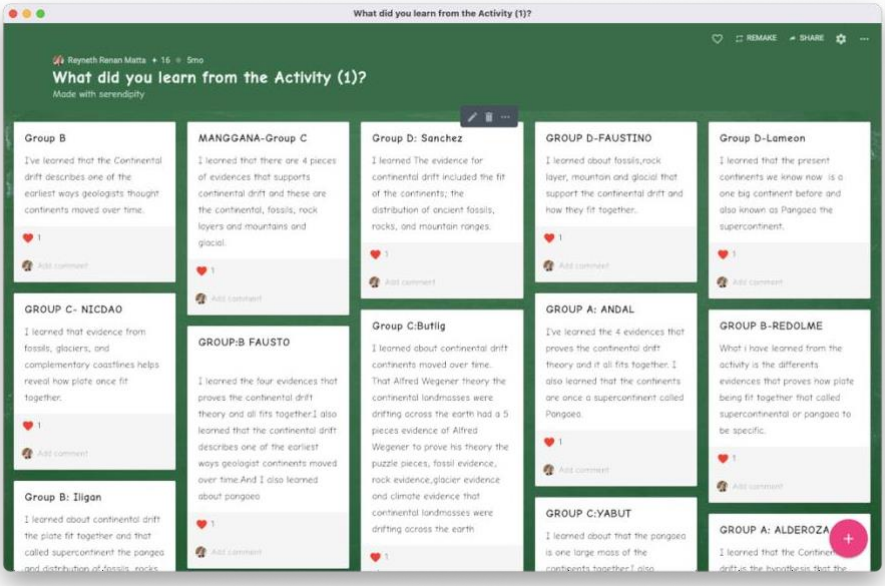


***Figure 3. The Innovative Teaching Padlet***

Padlet (www.padlet.com) as shown in Figure 3 is a free multimedia wall that encourages whole- class involvement by allowing real-time interaction between students as well as between students and the teacher (Fuchs, 2014). Padlet has been recognized as a valuable method for developing collaborative learning by a growing number of teachers in recent years. It has many benefits, including a) easy to use, b) instant communication (any student can see when another student is uploading something to the wall), c) multimedia (almost everything can be put on the Padlet), and d) mobile (it works on a variety of devices) (Zhi and Su, 2015).

- Past Experiences

| Table 5. Sample Transcribed Interviews | |
|---|---|
| Teacher Participant | Transcribed Inputs from all recorded data sources |
| T1 | *"This meeting allows me to share my past dealings with online class and be able to share it in lesson study"* |
| T5 | *"Observing scenarios in the first cycle allows me to reminisce how I teach in my class before the pandemic."* |
| T13 | *"Lesson Study allows me to share how I create interactive lessons like SIM and recently, ISIM (Interactive Student Intervention Materials).* |
| T19 | *"Giving me an opportunity to share my experiences before makes me reflect on how I can combine what I usually do before and what I learn here especially in developing science lessons.* |

Members of the lesson study group also shares past experiences on how they develop interactive lessons in their class during pre-covid days (see Table 5). Lesson Study provides collaborative discussions amongst teachers that enables them to give shared experiences. According to Roblyer, Porter, Bielefeldt, and Donalson (2009), past virtual experiences encouraged teachers

to reflect on their teaching and communication methods with students and work to develop more effective strategies and procedures for their online classes. Teachers can travel beyond their past teaching and learning experiences and view their teaching practices with a fresh start by using lesson study to explore the unfamiliar, daunting, and unpredictable environment of virtual learning (Roblyer, Porter, Bielefeldt, and Donalson, 2009).

The group base on their past experiences agrees that collaborative and inquiry-based learning should takes place even in online class. Recent studies have been conducted to see how online learning improves student-teacher capacity to learn and teach science, with the findings indicating that it is important to use all the teaching and learning approaches to online learning that go beyond traditional techniques. According to Mishra (2021), inquiry-based learning can be broken down into five steps: 1) Inquire, 2) Study, 3) Create, 4) Discuss, and 5) Reflect. In online research, all these measures are possible (see Table 6). Teachers may choose how involved they want to be in a student's learning of a concept and what part of the process will students are encouraged to do task collaboratively.

Table 6. Utilization of Inquiry-based and Collaborative Learning in Online Class

| Steps in Online Inquiry-Based Learning (Mishra, 2021) | Observed Flow of the First Recorded Research Lesson | Observed Flow of the Second Recorded Research Lesson | Leve of Collaborative Learning involved |
|---|---|---|---|
| Ask<br>Students are given a problem to solve. They must search into the problem/theory to prove it. To begin, the teacher can draw a graph, geometrical figure, or pictures on the whiteboard and begin the class by asking students questions about the image and asking them to begin searching for solutions to the problem. This is a simple move to duplicate in the online setup. | The first LS Implementor post the question using Microsoft PowerPoint as the opening activity. Using Google Meet each group in the class are tasked to seek for the solution to the problem.<br><br>Both Implementors discussed specific instructions during the online research class. | The second LS Implementor post the question from a discussion board (*Padlet*) as the opening activity. Using Google Meet each group in the class are tasked to seek for the solution to the problem.<br><br>Both Implementors discussed specific instructions during the online research class. | *Teacher – Student Student – Instructional Tool* |
| Investigate Students may be able to explore content using suitable web browsers, apps, and libraries to find answers to their questions. | Using what they learn from the asynchronous classes (videotaped lessons) and online modules, the group will seek for the answers on the provided question. | | *Teacher – Student Student – Instructional Tool<br>Student - Student* |
| Create<br>Create: After the students have completed their study, they must write papers, provide responses, or apply their findings to problems to | The class will enter the Google Meet Break Out Sessions and be able to post their answers in a white bond paper. | The class will enter the Google Meet Break Out Sessions and be able to post their answers in a Padlet. | *Teacher – Student Student – Instructional Tool* |

| | | | |
|---|---|---|---|
| illustrate their findings. The majority of this is conducted in front of the whole class. The teacher can hold a live online class where students can present their evidence. | | | *Student - Student* |
| Discuss and Reflect<br>After the proofs have been presented, instructors can hold an online discussion meeting to allow students to share their reflections and lessons from the entire process of solving the problem. | Groups from each class will present their work (white bond paper) to the class. Each group has their own roles in the group. | Groups from each class will present their work (Padlet) to the class.<br>Each group has their own roles in the group. | *Teacher – Student Student – Instructional Tool*<br>*Student - Student* |

- Schools Beliefs and Ongoing Practices

Teachers involved in the lesson study group shares their best ongoing practices in developing lessons based on their schools' beliefs pertaining to the webinars they've attended (see Table 7).

Table 7. Sample Transcribed Interviews

| Teacher Participant | Transcribed Inputs from all recorded data sources |
|---|---|
| T7 | *"Lessons must have LMS or Learning Management Systems like Google Classroom because that is the practice at school"* |
| T9 | *"We learn in a webinar that lessons must allow students to be grouped and meet virtually"* |
| T17 | *"Using the webinar our Division provides us, we can suggest that lessons should be highly collaborative in the online setting."* |
| T20 | *"Our teacher trainers at school provides a school-based training for teachers on how to us Google Meet and other Google Applications, that's why we are all using those because it's the school's instructional policy"* |

Given that beliefs are designated as having influence on and shape practices in the classroom (Ertmer & Ottenbreit-Leftwich, 2010; Prestridge, 2012a), the beliefs of teachers, principals and supervisors are important to identify. Principals and supervisors play a vital role in encouraging teacher change if he or she believes the importance of teacher support and gives them a chance to try innovative technical methodologies to implement modern teacher technologies in schools effectively (Somekh, 2008). School leadership should create changing environments that enable experimentation and innovation and include teachers in the process of decision making (Sociocultural, Reio, & Lasky, 2007).

When schools include facilitating the use of technology in the classroom, having a strategy, expressing the vision, sharing leadership, and rewarding teachers for their efforts to incorporate technology, it will give positive impact on teachers' classroom practices (Baylor & Ritchie, 2002).

Amongst the ongoing practices influenced by webinars shared by the lesson study group in developing science lessons are:

- For Asynchronous Class, *organized* Learning Management System (preferably Google Classroom)
- For Synchronous Class, *highly interactive and participative* Virtual Meetings (preferably Google Meet)

Instructional policies are mainly influenced by the webinars teachers are required / not required to attend to. According to White (2019), webinars are online conferences that take place over the internet. Meetings, conferences, demonstrations, training or teaching, or activities designed to provide knowledge in a one-way or interactive manner are examples.

*What are the critical areas in the online research lesson where science process skills are observed?*

The sections of the online learning lesson where students' science process skills are visible are referred to as critical areas. The lesson study group identifies the critical areas namely:

- Teachers-Student Interaction

The relationship between teachers and students is the most important aspect of education. Aside from students' interactions with their peers and learning resources, teachers and students must engage in a timely and appropriate manner (Swan, 2003).

The lesson study team discovered that when students encounter difficulties in their online learning, teacher feedback can correctly and efficiently guide students to reexamine their science process skills, overcome their deficiencies, and explore solutions to their problems. Such activities enable teachers to gain a better understanding of their students' learning processes, allowing them to observe and improve science process skills even in online mode.

- Classroom Activity

The lesson study group use case studies as the synchronous online classroom activity in line with problem-based learning in the online research lesson. Online case studies are situations in which students apply what they've learned in class (LMS) to a "real-world" situation. They are typically presented in narrative format and often include problem-solving, connecting lessons and modules during asynchronous class. As observed by the LS group, case studies are more useful when presented in order, so students can learn more as the case unfolds and continue to discuss or criticize the situation/problem. As such, contextualized and sequenced case studies are essential in observing science process skills related to analyzing and problem solving.

- Students Output

Student’s output is the product of learning or, to put it another way, the evidence that learning has taken place. In the online research lesson, the LS group learned that performance is critical since it demonstrates that students can apply what they've learned. And within these outputs in a form of performance to students, science process skills are evident and too noticeable. The output observed are the different responses / answers coming from the students in the Padlet and the presentation of these responses by the assigned member of the group in front of the virtual class.

*What are the different science process skills observed online?*

As the online research lesson progresses, lesson study acts as a "blueprint" for science teachers to check their own science process skills. Teachers build and observe the following science process skills (see Table 8) in students through collective discussions, evaluation, and post- conferences.

| Table 8. Science-Process Skills Observed in Teachers and Students | | |
|---|---|---|
| Skills | Definition | Examples |

| | | |
|---|---|---|
| Social Interaction Skills | ability to relate with others. | working with others reporting orally attending to what others find |
| Information Gathering Skills | ability to collect data of the surrounding environment | questioning observing measuring planning and conducting investigations |
| Analyzing and Reasoning Skills | ability to infer, test and give details | testing predictions drawing conclusions explaining |
| Communicating Skills | ability to collaborate with others | writing speaking listening arguing evaluating |

Conclusion and Recommendation

Utilizing the lesson study process in developing online lessons with science process skills were found to be effective because: 1) this is a continuous development model approach; 2) it focuses on the concept of learners' learning whether that is face to face or online; 3) it highlights professional teaching development in the context of actual teaching in the classroom; 4) it emphasizes shared learning within the lesson study / teacher group; 5) the teachers involved in implementing the research lessons see themselves as a supporting element in ensuring that science process skills are practiced and enhance even online.

The strength of the lesson study includes its meticulous, continuous, and sustainable development, emphasizing changes in the classroom, which require a significant level of innovation within its members. This is integrated into the framework of ongoing development or innovative open approach.

The lesson study group developed an online lesson that promotes problem-based learning with open-ended questions so that students could practice the science process skills. Students were provided contextualized problem scenarios, where many science process skills are to be observed. However, problem-based learning activities requires more time for students to express their science process skills. The lesson study group therefore reflected and evaluated on the outcome of the lesson together before improving them. The improved online research lessons become suitable to the time and improve students' science process skills.

The success of developing online lessons thru lesson study is determined by means of promoting social presence, interactions, and collaboration not just between the teacher's and student's but also within a group of teachers with expertise in dealing with online classes.

In line with this, lesson study has proven effective in enhancing the standards of science process skills and can be implemented in various contexts in different subjects.

## IV. Action Research Work Plan and Timelines

| **Research Tasks** | **Timeframe** |
|---|---|
| Reviewing and editing of the manuscript after its approval. | October 29, 2020 |
| Finalization of the themes and codes | November 9, 2020 |
| Data gathering. Pre-assessment to participants | November 11, 2020 |
| Implementation of Online Lesson Study in Science | November 13-16, 2020 |
| Data gathering on post assessment | November 24, 2020 |

| | |
|---|---|
| Analysis and computation of the data | January 5, 2021 |
| Writing and analyzing the draft | February 17, 2021 |
| Revision and finalization of the manuscript | March 15, 2021 |

## V. Cost Estimates

| **Research Materials Used** | **Costs** |
|---|---|
| Internet Connectivity | 2500 Php (Monthly) |
| Paper (Certificates) | 500 Php |

## VI. Plans for Dissemination and Utilization

| Title: **Development of Science Process Skills in Online Mode: A Lesson Study** |
|---|
| Project output:<br>a. Teacher-designed Lesson Study (Face to Face / Online) Matrix - the teacher researcher will craft a lesson study session where information about lesson study were to be introduced in other subjects. This is to ensure the correct implementation of lesson study and it will be aligned to the different subjects and contexts.<br>b. Video-taped Procedures of Lesson Study Implementation (Face to Face / Online) – the teacher researcher will show an actual implementation of Lesson Study both face to face and online (synchronous and asynchronous) for the teachers to see how it is done. |

Long term Impact: The project will help the teacher to uplift their professional development capacity in teaching both online and offline.

| Objective | Activity | Members in-charge | Date of implementation |
|---|---|---|---|
| Understand lesson study in the context of collaborative professional development model for teachers | Online Orientation for teachers | Principal Head Teachers Master Teachers Teachers | April 14, 2021 |
| | Online Department Meetings addressing the immediate focus of the lesson study to be addressed | Head Teachers Master Teachers Teachers | April 16, 2021 |
| | Online Department Meetings for the formation of the LS Group and implementation guidelines | Head Teachers Master Teachers Teachers | May, 2021 |

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