Developing the innovative inquiry-based lesson plan through lesson study

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Abstract. This study aims to develop an innovative inquiry-based lesson plan through lesson study (LS) [2]. LS is considered as an updated professional development which aims at improving the teaching process and students’ learning [16]. The lesson plan makes use of 7E learning cycle [5] embedded with inquiry activities that transform an ordinary classroom setting into an active student-centered learning environment [8]. The lesson model includes the following stages (1) Elicit, (2) Engage, (3) Explore, (4) Explain, (5) Elaborate, (6) Evaluate and (7) Extend. The research lesson made by the lesson study (LS) team was innovated gradually every after each implementation cycle. Revisions were done based on observations such as students’ responses, teacher-student interaction or student-student interaction depending on how students view the lesson and how the group activity work smoothly. The innovative lesson plan has refined three times, based on the needs of the students. It is also evident in the implementation that students’ learning and motivation are dependent on the scaffolding questions and the ability of the teacher to connect relationships that would help students contextualized the concepts in real life experiences.

1. Introduction

One of the major problems prevailing the fabrics of Philippine education today is the low achievement scores of Filipino students. Department of Education revealed in 2012 that the mean percentile score of Science-NAT in the country was 66.11% for the elementary and 40.53% for the secondary level [4]. Research studies revealed that teacher quality has a significant effect on students’ achievement [21]. Thus enhancing teachers’ quality is vital in improving the students’ learning outcome. Also, to enhance the ability and quality of teachers and the effectiveness of their lessons, teachers may engage in research activities like lesson study [14] The study pointed out that high-quality professional development focusing on higher order thinking skills and diversity issues do not appear to strongly influence classroom practice. Further studies showed that students’ success to understand the lesson depends on the ability of the teacher to facilitate the lesson properly [1]. This is the promising goal of inquiry-based learning and lesson study cycle which is intended to improve instruction given the realities in different classrooms.

Literature cited that Lesson Study (LS) in Japan is a fundamental driving force for mathematics teacher development. LS has been the primary mechanism of professional development for both prospective teachers and practicing teachers since the Japanese public education system started [14, 17]. It is a school-based collaborative activity for teachers mainly characterized by a continuous cycle of meticulous planning, prudent and mindful demonstrating, and perceptive improving a lesson. It is a
wide scope, the on-site professional development process that involves a small group of teachers. The teachers are of different levels of ability but with interest in working collaboratively, with specific objectives for lesson planning, to carry out the planned and researched lesson [7].

Through lesson study (LS), teachers can work together to develop an effective lesson for the students to maximize their learning experience [6]. Research studies also showed that the use of lesson study leads to instructional development since teachers become more aware of how students learn and think and how instruction affects student thinking. LS is a process in which teachers progressively strive to improve their teaching methods by working with other teachers to examine and critique one another’s teaching technique [10]. So, LS is not only for the good of students but for the teachers as well.

With this aforementioned views, this study elucidates how an innovative lesson is developed through lesson study cycle composting of two (2) in-service teachers and two (2) pre-service teachers. The product of LS is a refined lesson plan that make use of 7E Model [5]. This model or learning cycle consists of seven stages: elicit, engage, explore, explain, elaborate, evaluate, and extend, which allows teachers to present lessons that incorporate inquiry activities and promotes a student-centered classroom.

2. Theoretical Background

This study is anchored on the Constructivism Theory of Jean Piaget. Piaget suggested that students construct new knowledge from their experiences through “accommodation and assimilation”[18,19]. The study also pointed out that constructivism as a learning theory views learning as a process in which “students actively construct or build new ideas and concepts based upon prior knowledge and new information” [19]. Moreover, Constructivist teaching is based on the belief that learning occurs when learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information [17]. Lastly, constructivism activates the student's inborn curiosity about the real world to observe how things work and assume that all knowledge is constructed from the learner's previous knowledge, regardless of how one is taught. Hence, Constructivism modifies the role of teacher that he/she facilitates and help students to construct knowledge rather than to reproduce a series of facts [11].

A study claimed that there was an improvement in the competencies in the cognitive and manipulative skills of students, credibility, and commitment after the implementation of the constructivist teaching-learning process in chemistry laboratory subject [19]. In addition, students accept the constructivist teaching-learning process in their chemistry laboratory positively. Using a constructivist approach significantly improved how motivated are the students and the conceptual understanding of the students increased from low mastery to average mastery level [17].

This is the primary goal of Inquiry-based Approach. The inquiry-based instruction model stresses the learning and thinking process rather than just the acquisition of specific skills. It promotes the thinking process and teaches students how to process information in addition to skill and knowledge development. The focus of inquiry-based instruction is more on the actual process of learning than the understanding of specific concepts [3]. A further study claimed that inquiry-based teaching is a pedagogical approach as well as a learning strategy. Through the use of questioning, the core value of inquiry-based pedagogy puts stress on discovery learning and the development of learners’ cognitive skills and metacognitive strategies [12].

Hence, Huber et.al (2000) as cited by Easterly III (2011) taught that students using inquiry-based instruction have higher perceptions of science and have an increased achievement in science. The findings of Von Secker (2002) report that students being taught using inquiry-based instruction had higher content knowledge achievement than did students taught through other means [3]. Indeed, the inquiry-based approach is the heart of constructivism. Although it is not easy to be a constructivist teacher, this can be achieved through reforms in teachers’ training like engagement in a collaborative learning community such as lesson study.
3. Methods
This study is a kind of phenomenological inquiry that seeks to develop an innovative inquiry-based lesson plan through a community of learning - Lesson study. LS is a process that follows a cycle in which a group of science teachers works together, identify goals for the lesson, collaboratively developing a lesson plan, implementing the lesson (also called the Research Lesson) with observation by colleagues and other experts, analytically reflecting on the teaching and learning that happened, and revising the lesson. The lesson plan made by the team was revised along the three (3) implementation cycles. Briefly, the lesson study team entails the following: setting long-term goals for student development, planning a lesson together n an agreed topic, implementation of the lesson by a teacher while others observe and collect data on the lesson and students’ responses, post-lesson reflection and discussion and final revision of the lesson.

3.1. Planning of a Research Lesson
Prior to the lesson development, the LS study team started with a planning session that discusses and agree on how the lesson will flow from beginning to end. The team also decided to follow the 7E learning cycle of Eisenkraft, 2003 which involves inquiry-based activities that would stimulate students to think critically. Basically, the group does the following: share how to teach the lesson and how the students learn the topic; study available teaching and learning resources on the lesson; organize questions to be used in the processing of the students’ responses; developing lesson’s main ideas and assign the specific task of each member.

What roles do members of the lesson study team play?

3.1.1. Facilitator. The member who lead the meetings and be responsible for coordinating the activities of the group. The facilitator also moderates the post-lesson discussion and synthesizes the discussion made by the group and help integrate revisions into the lesson plan. 2) Documenter. The member of the group who what goes on during meetings, as well as agreements and decisions that the group will make. 3) Implementer. The member who is responsible for carrying out the lesson plan which the group has developed. 4) Observer. The main task is to observe and collect data about the lesson (student-teacher interaction) and students’ responses and reactions. The end product of the planning is a lesson plan embedded with inquiry-based activities using the 7E model.

3.2. Implementing the Research lesson
The research lesson was implemented to the 3 sections of grade 7 in Iligan City National High School namely: Grade 7-loyalty, grade 7-courage, and grade 7-prudence. During the implementation, a team member acts as a classroom teacher and carry out the lesson as planned while the other members just observed. The observers take note of what actually happened during the implementation such as modifications or deviations made; problems encountered by the teacher, difficulties experienced by the students and how these things were addressed; how the students responded to the lesson and what it revealed about their thinking and most importantly whether the learning competencies or objectives of the lesson were achieved.

3.3. Post-Lesson Discussion
After each lesson implementation, the LS group met for a post-lesson reflection and discussion. During this session, the members discuss what went well, how are the responses of the students, what problems or troubles encountered by the implementer and what things could be done to improve the lesson. The team also reflected on how students think and learn as indicated by evidence gathered during implementation. The focus of post-lesson discussion is not the teacher but on the lesson and the responses of the students. The research lesson was then revised based on the observations made and insights of the group and other ideas that resulted in the group discussion.
4. Results and Discussion

The figure 1 below is the process of implementing the lesson study. It shows how the (LS) Lesson study team work together to develop an innovative inquiry-based lesson plan. Moreover, an inquiry-based lesson plan had adopted the 7E learning cycle model of Eisenkraft (2003), developed and implemented to grade 7 students in junior high school. The teachers then revised the lesson plan during the post-lesson discussion based on the learners’ difficulties and learning.

Throughout the three implementation cycles, several changes in the inquiry-based activities, questioning technique and in sequencing details were made. These changes were based on the responses of the students during the student-teacher interaction and student-student interaction towards the lesson. Post lesson discussion and lesson revisions were done every after implementation cycle.

*Elicit Phase.* In the elicit phase, a game called “4 pics one word” were given to the students in order to access the students’ prior knowledge. The implementer showed four pictures on the board, with blank spaces that correspond to the number of letters of the word. The students would come up with a word that best describes the four pictures. They would raise their hand if they know the answer. After the game, an image of an identical twin; which is Raymond and Richard, is shown to the students and questions about the image would be thrown to them. The questions were: “Why are identical twins look similar?”, “What makes them similar?” and “Do they have the same genetic material?”

![Figure 1 Lesson Study Process](image-url)
ELICIT (Access prior knowledge) (5 mins.)

To access and check the prior knowledge of the students towards the topic, the teacher will let the class play a “4 pics 1-word” game/activity in which they will guess the hidden word behind the pictures that will be shown. The teacher will list down the words given by the students such as organisms, twin, identical, two, similar, reproduce, replicate, etc. Let the students construct a sentence out of the given words.

The teacher will then connect their answers with the idea of producing identical twins. After the game/activity, another picture of an identical twin will be shown to the students and some questions will be raised by the teacher to support the picture.

The questions will be the following;
1. Do you know them?
2. How do they look? Similar or different?
3. Why do identical twins look similar?
4. Do they have the same genetic material? (If students would answer YES, 5. How are identical twins produced? Allow the students to explain on their own.

Answer: To form an identical twin one fertilized egg (ovum) splits and develops into two babies with exactly the same genetic information. The concept behind identical twins is the cell division known as the mitosis. Mitosis is one of the two types of cell division that produced two identical cells. Another type of cell division is the meiosis that has the same process and its only difference is that the process in meiosis happens twice and its product is 4 unique haploid cells.
During the first implementation cycle, the observers and the knowledgeable others observed that the students had some difficulties in getting the correct word that sums up the 4 pictures. The pictures were confusing for them because it does not clearly describe the words and others were images that they were not familiar with. On the other part, students were not able to answer the questions, it was so hard for them since they were not familiar with the deeper concepts of identical twins. In the whole phase, the students were not able to participate actively. So in the second implementation cycle, in order to catch the attention of the students and they would be able to give the right word, the researchers decided to change the pictures that were confusing for the students. In the word “twin or identical”, one of the pictures was changed into an image of Richard and Raymond which the students were familiar with, while in the word “growth” other pictures were changed into much more obvious images like a growth of a human being and a plant. For the second part, scaffolding questions were added for the students' aid. The questions were; “Do you know them?”, “How do they look?”. However, in this implementation cycle, another problem arises; the students were so noisy and the class was a mess because they all want to be called by the implementer to give the right word. The implementer was not able to control the eagerness of the students to answer. Others were even angry for they were not called by the implementer when they say they were the first one to race their hand. So for the third implementation cycle, to lessen the noise and to make the class organized, the researchers decided to make the activity by the group in order to avoid such a scenario. The class was group into 7 groups and each group was given a tag board and chalk where they would write their answer and whoever raises their tagboard first that had the correct answer gained the points. To attract more participation from the students, the researchers were also giving prizes to the groups or students that was the winner or answers the questions correctly.

*Engage Phase:* In this phase, in order to continue to excite and engage students mind in the lesson, the implementer showed an image of a fraternal twin; which the students were familiar with, and that was a picture of Mavy and Cassy Legaspi. The implementer then threw some interesting questions to the students and discuss the relation of fraternal twins and identical twins. The questions given to the students were; “Why are fraternal twins look different?”, “Do they have the same parents?”

**ENGAGE (Get the students’ mind focused on the topic.) (7 mins.)**

This time, a picture of a fraternal twin will be shown so that the students will be curious about what are the differences between the two types of a twin. It will help the students to focus their mind on the topic.

What do you think is this kind of twins?

**Answer:**

Fraternal twins

The teacher might ask some follow up questions to the students to support the picture above.

1. Why do fraternal twins look different?
2. Do they have different parents? So how come that they look different?

Fraternal twins look different even they have the same parents. This is an application or a product of a type of cell division called meiosis.
Unfortunately, in the first implementation cycle, the observer noticed that the students had no prior knowledge about the questions asked and they were not also familiar to the explanation to why fraternal twins look different. Because of that, their answers to the questions were mostly guessed. So, for the second implementation cycle, in order to avoid confusion and guessing, the researchers gave scaffolding questions to the students, these questions were: “how do they look?” and “are fraternal twins look different?” Other questions that may be hard for the students to answer were diminished and were placed in optional. As a result, in this implementation cycle, students were more responsive and showed interest in the discussion about the fraternal twins. So the researchers agreed not to revise it for the third implementation cycle.

**Explore Phase:** In order for students to explore new knowledge, the implementer gave a group activity that made the students solve problems on their own with the aid of instructions and given materials. In this activity, the students were given one set of drinking straw and four plastic cellophanes in a paper box. Then the implementer would instruct the students to divide the straws equally into four. In connection to what they just did, the implementer would ask questions to the students. After the activity, a short overview of meiosis would be discussed by the implementer. In the first implementation cycle, the researchers saw that not all of the groups were able to follow the instructions well. Other groups divided the straws into 2 or 3. The instruction was not clearly stated and was not repeated which made it confusing to the students on what they really need to do. Observers also stated that the questions were difficult for the students since it was too confusing. Lastly, students also find it difficult to imagine the discussion of the overview of meiosis without any instructional materials. Hence, for the second implementation cycle, in order for the students to follow the instructions correctly, the researchers emphasized that the instructions must be clearly stated and should be repeated many times so that all of the groups would be able to follow correctly. Secondly, unnecessary questions were removed to avoid confusion, from 9, the researchers reduced it into 4 questions which were: “what are your bases in dividing it that way?”, “what does the plastic container represent? Pair of straws?”, “do you have similar combinations of straws per container?”, and lastly “what are the combinations of straws do you have?”. In the discussion of the overview of meiosis, since most of the students were visual learners, and so that students wouldn't have a hard time imagining the discussion, the researchers decided to make a 3d model that shows the division of cells and its uniqueness. However, during this implementation cycle, the observers saw that students had some confusions in the questions. This is because the questions were shuffled and the students were having a hard time connecting the dots. So, another revision was made for the third implementation cycle, this was to make the questions much easier to answer and to avoid confusions. The questions were rearranged from simple to complex. As a result, students were able to answer the questions without difficulty and confusion.

**Explain Phase:** This phase is where the implementer discussed the lesson, which is the meiosis. The implementer would explain thoroughly and clearly each phase of meiosis which were; Prophase, Metaphase, Anaphase, Telophase. Interaction and active participation from the students were encouraged here. During the discussion, simple questions were thrown to the students as an opportunity for them to participate. Unfortunately, in the first implementation cycle, students were shy to raise their hands and others don’t even bother to participate. The observers could observe that the students were a little intimidated because it was their first time meeting the implementer. So, they were not yet comfortable to answer questions. So, for the second and third implementation cycle, an alternative way to get students attention and participation was made. This was giving food or candy prizes to the students who choose to participate. Each student that raises his/her hand and give the right answer shall have a prize. It went well and made the students more eager to answer simple questions.
EXPLAIN (Teach the concept. Should include interaction between teacher and students). (22 mins.)

In this phase, the students will discuss their idea of the 8 stages of the meiosis. The implementer will guide them to the right track and give them clues.

Meiosis is a type of cell division that results in four daughter cells each with half the number of chromosomes of the parent cell. It has eight stages namely: prophase 1, metaphase 1, anaphase 1, telophase 1, prophase 2, metaphase 2, anaphase 2, and telophase 2. This is divided into two parts which are the meiosis 1 and meiosis 2.

Prior to meiosis, preparation of the cell takes place, chromosomes and centrosome will duplicate.

**Question:** do you have any idea what phase is this?

After that, the first phase of meiosis follows.

**Question:** what is the first phase of meiosis 1?

**Question:** what will happen in prophase 1?

Prophase 1 is the longest and the most important part of meiosis. Aside from the activities that is already mention. synopsis which is the pairing of homologous chromosomes will occur and crossing over will take place. Crossing over is the process that can give rise to genetic recombination.

**Question:** how about the second phase of meiosis 1?

**Question:** what happened during metaphase 1?

The third phase of meiosis is anaphase 1.

**Question:** what is the activity during anaphase 1?

The students participate in the discussion and give their ideas on the 8 stages of meiosis.

**Response:** “just like in mitosis, this phase is called the interphase”

**Response:** “the first phase if meiosis is prophase 1”

**Response:** “In prophase 1, chromosomes will coil and become shorter and thicker. The nucleolus will disappear, spindle fibers will start to form and centrosome migrate towards the opposite poles.”

**Response:** “the second phase of meiosis is the metaphase 1”

**Response:** “In metaphase just like in mitosis, centrioles are at the opposite poles of the cell. The chromosomes will align at the middle of the cell which is called the metaphase plate and spindle fibers from one pole of the cell will attach to one chromosome of each pair.”

**Response:** “During anaphase 1, chromosomes separate and start moving toward opposite poles of the cell as a result of the action of the spindle fibers.”

**Elaborate Phase:** This phase provides an opportunity for students to apply their knowledge to new areas. So the implementer provides a group activity that will assess the students learning or knowledge about the lesson and enhanced the students’ collaboration. In this group activity, the implementer
would assign one phase for each group. A strip of paper that has a certain phase and it’s meaning was given to each group. They would draw and explain the phase that was assigned to them.

ELABORATE (Students apply the information learned in explain.)

In this phase, the implementer will show a picture of prophase that is ready for recombination and let the students predict the possible color combination if it will undergo the first meiotic division.

The picture above is an example. The following question will be thrown to the students.
Questions:
1. What stage of meiosis is shown in the drawing?
2. What if this prophase will undergo first meiotic division?
3. What are the possible color combinations in each cell?
4. Can you think of other combination aside from these two?

After the questions, the implementer will then discuss the activity. The implementer will let the students realized that one pair of chromosomes could have thousands of possible combinations. This is why siblings or even fraternal twins may have their similarities but they will not be exactly alike.

During this activity, the students were eager to give the possible color combinations. They were so excited that even other students went to the front to give their answer.

Question: what stage of meiosis is shown in the drawing?
Response: the stage shown in the picture is prophase 1.

Question: what if this prophase will undergo first meiotic division?
Response: “homologous chromosomes will separate”

Question: what are the possible color combination in each cell?
Response: “big green and small red or big red and small green”

Question: can you think of other combination aside from these two?
Responses:
S1: “big green and small green”
S2: “big red and small red”

In the first implementation cycle, the group activity did not go well. Majority of the group outputs did not match to the phases that were given to them and they cannot explain the phase that they drew. The students were not able to familiarize the pictures of the phases from the discussion. In connection with this result, the activity was too difficult for the students. So, the researchers decided to change the whole activity for the next implementation cycle into something that students can enjoy and at the same time learn. In the second implementation cycle, a picture of one of the stages of meiosis is shown to the students. The implementer then asked a series of questions which were; “What stage of meiosis is shown in the drawing?” “What if this prophase will undergo first meiotic division”? “What are the possible color combinations in each cell?” and “Can you think of other combination aside from these two?”. This activity drew students attention that made them participate actively and attentively. Despite being one of the last stages, students were excited to answer what stage is shown and eager to predict the color combinations of the chromosomes. Without even noticing, while having fun, the
students were able to learn and develop their predicting skills. Given the result, the researchers decided not to revise this phase for the next implementation cycle.

**Extend Phase:** In order for the students to apply their knowledge to real life situations the implementer showed an image of the Barreto sisters and asked two questions which were; “Why do sibling who have the same parents look so different?” and “What specific activity that results to the diversity of individual?”. Throughout the three implementation cycle, most of the students were able to answer the questions confidently. They were able to relate the topic to why siblings with the same parents look so different. This implies that the students learned from the lesson and were able to apply their new knowledge to real life setting.

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**EXTEND (Deepen conceptual understanding through the use of new context)**

In this phase, the teacher will show the image above (Barreto sisters) and asked the following questions.

**Questions:**
1. Why do siblings who have the same parents look so different?
2. What specific activity that results in the diversity of the individual?

This context is in connection with the concept of meiosis, which is the cell division that results in four unique haploid cells. Each cell is different that is why even siblings that have the same parents look different. During the process of meiosis in the prophase 1, crossing over takes place. This is an activity where genes from the mother and the father recombine resulting in the diversity of each individual.

In this phase, the students will apply their new knowledge to real life setting.

**Question:** why do siblings who have the same parents look so different?

**Response:** “siblings who have the same parents look different because of the cell division called meiosis.”

**Question:** what specific activity that results in the diversity of individual?

**Response:** “the activity that results in the diversity of individual takes place during prophase 1 and that is the crossing over”

The students were amazed by the application of the lesson and they were so thankful that they learn something meaningful.

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5. **Conclusion**

Based on the findings of the three implementation cycles, LS provides a good opportunity for the team to develop and innovate a good lesson plan based on the responses of the students during the student-teacher interaction and student-student interactions. It also promotes cooperation and collaboration among members of the LS team to create a meaningful learning environment. Despite the limited resources, teacher implementer was able to show better ways to teach the particular topic because of the critical reflection during the post-lesson discussion. LS is a good practice in the education industry, to come up, not with the best lesson but the most appropriate lesson for the learners.

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