Scaffolding Teacher Learning through Lesson Study[1]

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At the end of the day, success of any reform in education to raise students' achievement will still be a function of how the teachers implement the reform. Hence, a key towards turning the tide around for the continuing decline in students' achievement will still be through those that deal with the learners directly— the teachers. Studies show that the ways to go to implementing effective and sustainable educational reform will be through an inquiry-type professional development program of teachers, while they are *in action* (NCTM, 1994). One of these professional development models that has proven effective in Japan and is now being implemented in many countries is *lesson study*. This chapter discusses the development of a model of scaffolding teacher learning in the context of lesson study. It also presents evidence of the potential of lesson study to expand teacher repertoire of knowledge and skills in teaching.

Stigler and Hiebert (1999) in *The Teaching Gap: Best Ideas from the World's Teachers for Improving Education in the Classroom* identified lesson study as the crucial factor of Japan's high achievement especially in mathematics education (see also Fernandez & Yoshida, 2009; Lewis, Perry, & Murata, 2006). Lesson study started in Japan in 1872. By the middle of 1960, it was well established as a strategy of in-service teacher training and since then has been the primary professional development activity of their in-service teachers (Fernandez & Yoshida, 2004). After the release of *The Teaching Gap,* lesson study started to become popular in the US as well and the rest of the world including Asia. The World Association of Lesson Study (WALS) has been holding an annual international conference on lesson study since 2007. The Asia Pacific Economic Cooperation (APEC) had also been holding forums for promoting lesson study especially in the Asia Pacific Region.

Lesson study is a model of school-based, teacher-led professional development (Lewis, 2002c). It is conducted by a group of classroom teachers working *collaboratively* to *design* instruction and *study* student learning by *systematic inquiry*. In lesson study, teachers are engaged in critical, creative, and collaborative work in developing and

[1] To cite this article: Ronda, E. (2013). Scaffolding teacher learning though lesson study. In S. Ulep, A.Punzalan, M. Ferido, & R. Reyes (Eds.), *Lesson study: Planning together, learning together* (pp. 195-216). Quezon City, Philippines: UPNISMED

researching a single lesson through a "design-implement-reflect-revise" cycle that addresses the goal they initially set at the beginning of the lesson study. Studying a lesson in-depth in this process affords teachers the chance to get insights into students thinking and how they learn. Thus, it is a form of action research by teachers about their own teaching. The objective is not to develop a 'perfect' lesson but to make the development of the lesson a context for the teachers to increase their repertoire of knowledge on the different ways of interpreting and representing content topics in a form that is learnable by their students and to study in a deeper level how students learn and understand a particular content.

In 1986, Shulman (1986) introduced pedagogical content knowledge (PCK) as a different form of knowledge from content (subject-matter) knowledge and curricular knowledge. Since then, many others have contributed towards defining and describing it. Shulman described PCK as "the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by students" (1987, p. 15). At the heart of this construct are the following: (1) knowledge of interpreting the content, (2) knowledge of the different ways of representing it to the learner, and (3) knowledge of learners' potential difficulties, misconceptions, and prior conceptions. All these come into play when teachers engage in lesson study. In mathematics, PCK has been called mathematics-for-teaching knowledge or mathematical knowledge for teaching (MKT). It has been shown in studies that teachers' MKT does predict positive gains in students' achievement (see for e.g., Hill, Rowan, & Ball, 2005).

Traditionally, pre-service curriculum tends to give more emphasis on acquiring content knowledge and knowledge of general pedagogy. While it can be argued that those engaged in the training of prospective teachers are now redesigning their curriculum to give more time in developing PCK, pre-service education will still not be enough to equip them with this knowledge. Teachers usually learn PCK when they are already teaching and interacting with students. However, even in the classroom context, teachers' acquisition of this knowledge is not deliberate and systematic. Lesson study offers them a venue to increase their repertoire of PCK and learn it in a more systematic and focused way (see Fig. 1).

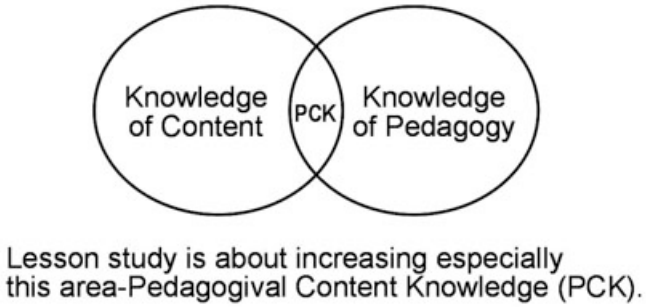

Fig. 1. Lesson study and PCK.

In the Philippines, there is much to be desired in teachers' content knowledge and pedagogical content knowledge as shown in the performance in the Licensure Examination for Teachers (LET) and in the recently concluded TEDS-M study (TEDS-M, 2012). Students' performance in international examinations such as the series of Third/Trends in International Mathematics and Science Study (see e.g., TIMSS Philippine Report, 2003) that the country participated in and in the country's national examinations leave one to ask questions regarding the state of our education and with it the kind of instruction the students are receiving. (Of course, there are other factors like large class sizes, teachers' load, and inadequate curriculum resources that contribute to this state). Clearly, the teachers need support for their professional development. However, there are only few opportunities for many Filipino teachers to attend professional development programs and the few who do usually attend in-service trainings, seminars and conferences, which are usually one-time deals and may not directly be about teaching the content. Because lesson study is school-based, all the teachers can participate. The teachers investigate with their co-teachers the lesson they themselves designed.

Lesson study requires collaboration with other teachers from planning to teaching and revising of a particular lesson. However, this is not yet part of the school culture. Collaborating with other teachers to design a lesson and implement it while other teachers observe are still something unheard of and inconceivable for many in the Philippine setting. Thus, when introducing lesson study to teachers, sensitivity to this existing culture is necessary especially that lesson study is also about changing this culture towards creating a community of practice and strengthening support system.

In 2006, the National Institute for Science and Mathematics Education Development of the University of the Philippines (UP NISMED) launched the project Collaborative Lesson Research and Development (see p. 3). The project has two-fold objectives. The first is to design a model of introducing lesson study in schools and the second is to promote the strategy of teaching through problem solving for mathematics and inquiry-based teaching for science. In Japan, mathematics is predominantly taught and learned in the context of

solving problems. This strategy of teaching mathematics has been known as Teaching through Problem Solving (TtPS). It is claimed that this approach is a product of Japan's long history of doing lesson study (Isoda & Nakamura, 2010). See pp. 3 to 4 for a detailed description of TtPS.

This chapter describes the model developed for introducing lesson study and promoting teaching through problem solving. The process describes how we scaffold teacher learning at the macro and micro levels as we introduce lesson study to the teachers. In education, scaffolding (Wood, Bruner, & Ross, 1976) is a metaphor for describing a way of how a teacher facilitates learning to support students' own construction of knowledge that was *initially* beyond the students' capability. In this study, the term *scaffolding* is used to describe the tasks/activities and facilitating provided to support teachers' own construction of knowledge for teaching content. Hence, the scaffoldings were only provided when needed, and was gradually withdrawn as the learner (the teacher in this case) gains more skills and knowledge to become an independent learner. The macro level scaffolding involved more of the processes/activities used to initiate the teachers in the processes of lesson study and the micro level scaffolding involved more of the way we facilitated the lesson study groups. The type of facilitating provided was as described by Goldman (2001):

> Facilitating teachers' learning includes the need for teachers to learn new ways to talk about content and student thinking and to articulate their knowledge of content and pedagogy in greater detail (p. 36).

The activities/scaffolding provided to the teachers also gave emphasis on reflection, collaboration, and problem solving. By problem solving, we refer to the lesson study group problematizing instruction and learning.

Introducing lesson study in schools

The 2006 model

Two models of introducing lesson study were used since the start of the project. The first model was implemented in 2006 for mathematics in two secondary and two elementary public schools. The process is shown in Fig. 2. The 2006 model included a 3-day orientation seminar about lesson study, teaching mathematics through problem solving, and developing higher-order thinking skills. After the orientation, facilitators from NISMED visited the schools to organize the lesson study groups. The number of meetings with the lesson study groups, which lasted for about an hour, varied for each year level. The NISMED staff facilitated teachers' goal setting, designing the lesson, implementation, and post-lesson discussion and revision. The following year the NISMED facilitator went

back to the school for the next cycle of implementation of the revised lessons and started with another research lesson. Some lesson study groups had three cycles, some only had two.

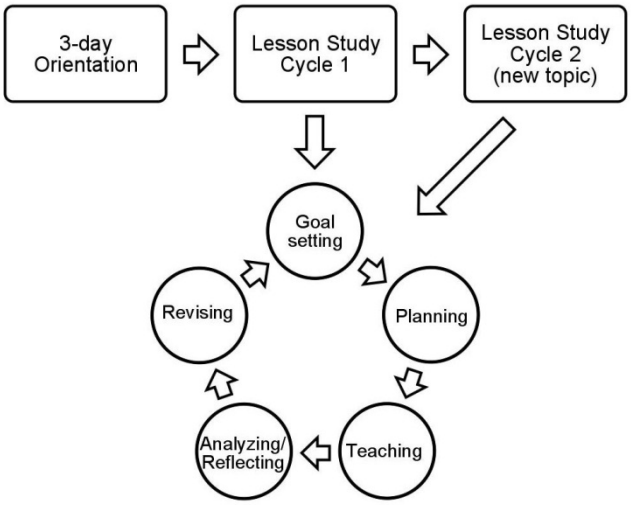

Fig. 2. Introducing Lesson Study 2006 Model.

The results of the project were very encouraging. The following excerpts were from the interviews with the group of high school Mathematics I teachers at the end of three cycles of their experience in doing lesson study. (Filipino words are in italics. English translations are in parentheses.) Their comments and reflections after the three cycles of doing lesson study centered on the strategies used in teaching and what is gained by collaborating with one another.

> *Yung* collaborative lesson planning *maganda siya kasi iba't ibang* idea *nung* teachers *ang pumapasok, parang kung baga sa* test *may* validity test. *Yun parang nagiging* valid *na yung* test *kasi ita*-try *mo* once*, tapos pag meron kang dapat alisin o babaguhin* then again try, *kaya parang napapaganda mo talaga yung pagpi*-present *ng* lesson*, hindi isang beses mo lang ginawa* after *nun wala na kaya siya [lesson study] maganda sa akin*. (The collaborative lesson planning is good because teachers contribute different ideas; it has validity, just like in the test. The lesson becomes valid because you get to try the lesson out and try to improve it each time. You don't deliver the lesson once only).
>
> *Maganda kasi yung* problem solving *Mam, hindi ka na tatanungin kung saan yung gamit ng* math*, … alam na nila yung* problem, about *yung sino*-solve *nila, parang naisip na nila, parang na*-appreciate *na nila*. (I like the problem

solving [strategy] because the students need not have to ask what is the application of the math they are learning, … they know through the problem, they can figure out from the problem the application of the math. I think they (students) appreciated it.)

[In Lesson Study] *parang in*introduce *nyo sa amin na* on how to introduce the lesson, *na hindi siya yung* traditional way, *parang nag*-deviate *kami* from traditional way *na talagang parang tinuruan namin ang batang mag-isip, hindi na* spoon feeding, *na hindi na eto yung* lesson, definition *na agad ng* lesson, *hindi, bata ang nakakakuha, siya nakaka*-discover, *siya ang nagde*-derive *ng* formula, and so *sa tingin ko mas nage*-enjoy *ang bata at mas matututo sila*. (In Lesson Study, it's like you helped us on how to introduce the lesson, which is not the traditional way. We deviated from the traditional way. It's like we are teaching the students how to think. It was not spoon-feeding. It's no longer as we used to do: here's our lesson and we right away give the definitions of concepts. It wasn't like that. It's the students who make the discovery, they are the ones deriving the formula. This is why I think the students enjoyed it and I think they learn more.)

However, challenges were also encountered in creating a collaborative environment especially in the planning part of the lesson. Lesson study is anchored on the assumption that teacher learning occurs through interaction with other people where they receive feedback, hence, the necessity for the teachers to work collaboratively. The problem was not only finding a common time for meetings but the teachers themselves do not seem to see the need for collaborating in planning the lesson especially during the earlier group meetings. One possible explanation for these is that the teachers do not see any problem in their teaching and are already happy with their students' level of understanding of the content topic. However, the facilitators know that their test items in the periodical tests and long tests were largely on computational procedures, which indicates the emphasis of their teaching, and not on conceptual understanding and problem solving. Clearly, there is a need for creating a situation where the teachers will see the need for collaboration, as well as teaching for conceptual understanding.

The post-lesson discussion also needs to be improved. The teachers' comments were limited to comments about the lesson being carried out as planned and whether or not students were able to solve the problem or not, despite the facilitator's effort to direct the discussion to students' solutions, difficulties and misconceptions. It

seemed that the teachers have not appreciated the importance of knowing their students' difficulties, and misconceptions and how they learn particular content as valuable inputs in designing effective instruction. This observation is perhaps typical. In the study of Even and Tirosh (1995), they concluded that "many of the[ir] teachers made no attempt at understanding the sources of students' responses. […] Therefore, we suggest that teacher's awareness of sources of students responses be developed." We addressed these concerns in our revised model.

The 2010 Model

The 2006 model of introducing lesson study was revised in 2010. Data were also collected on how it supports teachers' mathematics teaching knowledge. This section describes the model that was used in 2010 including some evidence of teachers' learning.

Four lesson study groups were organized, one for each year level of a public high school. The school has about 5000 students. Each group was composed of four to five teachers teaching mathematics in the same year level. Topics, hours of planning, and implementing in each group varied but in general, all the groups went through the same process. However, in describing the model, reference will be on the Mathematics I lesson study group facilitated by the author.

The Mathematics I lesson study group is composed of five mathematics teachers. Except for one of them who had been teaching mathematics for 13 years, the members' teaching experience ranged from two months to five years. The author's role as facilitator of the group was to introduce the teachers to the lesson study process and provide feedback and suggestions as needed.

The diagram in Fig. 3 describes the 2010 model of introducing lesson study. Steps 1 and 5 were not part of the 2006 model but were added to further help the teacher reflect about their practice. Fig. 3 shown in the photo "scaffolding at the macro level." The micro level scaffoldings were the questions the NISMED staff facilitators asked at each stage of the process. In the diagram, the area covered by the facilitator's input is decreasing while the teachers' input during the process increases.

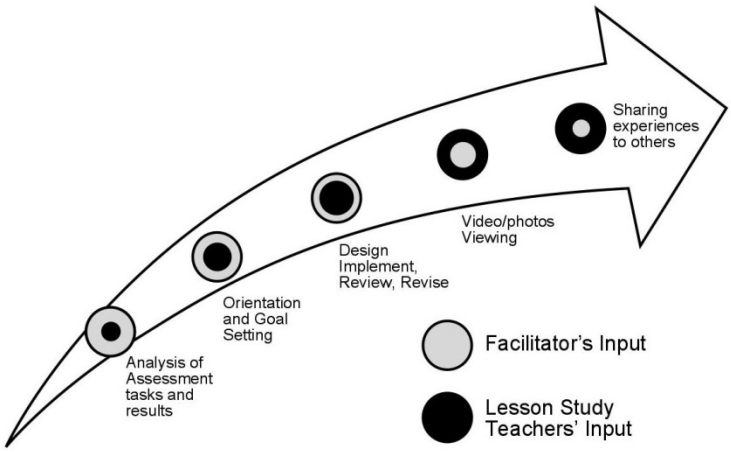

Fig. 3. Introducing Lesson Study 2010 Model - Cycle 1.

1. Analysis of assessment tasks and results

One of the components of PCK that was deemed important for the teachers to learn is knowledge of students' difficulties and misconceptions. From the 2006 model experience, discussing the latter in post lesson discussion alone will not be enough to make the teachers realize the importance of this knowledge. So, before the conduct of the lesson study for SY 2010, data were collected using a test about students' understanding of concepts contained in a unit or chapter from which the teachers will make the research lesson. The tasks are non-standard textbook tasks and involve searching for patterns, making generalization, relational thinking, and reasoning. In Mathematics I, the test was about understanding of and operation on integers, one of the most difficult topics in this level. From this unit, the Mathematics I lesson study group will choose one topic for their lesson study.

The test was given to Mathematics I classes in February 2010. This means that they have already covered the topic earlier in the year. Before the end of the school year in April, the Mathematics I teachers and the author met to discuss the test questions and examine selected students' test papers.

The following questions were asked during the discussion in order to make the teacher reflect on the kind of tasks they provide the students and to encourage them to look deeply in the result of the test: What do you notice about these tasks? How are they similar/ different from the ones you are using? How will your students answer these questions? Which item will they find easy? Difficult? How will you classify students' responses? What was the student thinking when he or she answered that way (after examining sample responses)?

Most lesson studies, in fact, start from identifying students' difficulties. Some, use the results of the tests while some identify students' difficulties based on their experience. What we have done here is to develop 'rich tasks' that will both serve as prototype tasks that the teacher can use in the lesson as well as draw out a variety of responses from the students to get started with the discussion about students understanding of the topic selected for lesson study. These also served as reference points during the planning stage and during the post lesson discussion.

The objectives of this stage are:

a. To expose the teachers to rich, open-ended mathematical tasks that are potentially useful in teaching/assessing understanding of integers and their operation;
b. To collect a range of correct and incorrect students' solutions and reasoning which the LS group can use in the planning of the lesson; and
c. To start the teacher thinking in terms of the way students think when examining students' responses and reasoning.

2. Orientation and goal setting

Inasmuch as the teachers do not know yet what lesson study is and how to do lesson study, it was necessary to organize a seminar for this purpose before the start of the school year. The seminar included the following activities:

a. Orientation about lesson study;
b. A lecture/workshop about the nature of mathematics and its implication to teaching and assessment;
c. A sample mathematics lesson by NISMED staff with the teachers acting as students;
d. A video of lesson implementation and post- lesson discussion of teachers from previous lesson study; and
e. Goal-setting activity.

The purpose of the demonstration lesson and video lesson were to show to the teachers how a 'preferred' approach of teaching mathematics, which was named "teaching mathematics through problem solving", is conducted. The video showed how post-lesson discussion of the lesson was conducted. This is to give the teachers an idea how lessons are analyzed and which areas or aspects are given emphasis during post-lesson discussion in a lesson study. The questions asked during the analysis of the lesson were structured in a way that will make the teacher see that the lessons teach

more than the content of mathematics and that it emphasizes the development of higher-order thinking skills and mathematical processes such as representations, making generalization from patterns, and solving problems in different ways. This is also a way of influencing the teachers to consider these thinking skills and processes when they formulate their lesson study goal and in designing the lessons.

3. Design, Implement, Review and Revise Cycle

Design-Implement-Review and Revise cycle is the core of the lesson study. At the start of the planning session, the teachers were asked to share to the group how they teach the chapter about real numbers and more specifically, on integers; what they emphasize in the lessons, and how they assess students' learning. The teachers were then asked to make an outline of the topics covered in the unit and the time it takes them to cover the whole unit.

In choosing the topic, the teachers were asked to identify which particular topic was the most difficult for students to learn. The group chose to do a lesson study on subtraction of integers. Some of the scaffolding questions asked during the planning stage include

a. What are the important ideas and skills do you want your students to learn after the unit on operations with integers?
b. How will you use the activities in the preceding lessons to teach subtraction of integers?
c. Do you think there are other lessons where these activities can still be useful or relate to? and
d. What are the students' difficulties on integers particularly in subtracting integers?

It appears (and the teachers themselves admitted) that they do not think of these factors when they plan their lessons. When they plan their lesson for a topic, the teachers do not consider how it links with other lessons and how the activities may be connected. They also do not factor in much how students think and learn a particular concept and the reason behind their difficulties when they plan the lessons. This was shared by one of the teachers in an interview.

The study of integers was supposed to be in the second chapter but the schools division to which the school belongs decided to put it in the first chapter. Hence, the group only had two weeks to organize their thoughts and put in the details of the lesson plan. The teachers were met with the author three times during those two weeks but in between the meetings, they also met among themselves to discuss and plan the lesson.

The meetings were conducted after school hours. During the planning 206 stage, the author also had the chance to observe the teacher in their classes. This was a valuable input as facilitator of the lesson study group as the author had the chance to see how the teachers teach before the implementation of the lesson study and what the students were learning before the conduct of the research lesson.

During the implementation of the lesson, the teachers observed and listened to the discussion of groups of students assigned to them. The purpose of the activity is for the teachers to learn more about how their students think and learn and to use these data for the improvement of the lesson. In the case of Mathematics I lesson study group, three teachers implemented the lessons in their classes with all the other members present. However, they all carried out the same lesson in all their classes.

A post-lesson discussion after every lesson implementation was done. This is the part where the lesson study group analyzed the lesson and the students' responses and behavior during the lesson. The one who implemented the lesson is the first to start their sharing followed by the sharing and suggestions of the other members. Questions asked to start the discussion were:

a. In what part of the lesson were you happy about and why? Which parts need revising?
b. What misconceptions did you identify? and
c. What were the students' difficulties? How can they be addressed? The teachers also shared their experience of teaching the lesson and students' solutions and questions from their other classes during the post lesson discussion.

4. Selected footages/photo viewing

Three weeks after the last implementation of the lessons, teachers were interviewed about their experience in the lesson study and what changes they observed about their students and in the way they teach. The teachers said they noticed that thinking is now more evident in their students because they now asked questions. However, while they appreciated lesson study and the teaching method learned from it and have tried it with two more topics, they said they have gone back to their old way of teaching because they were trying to cover the syllabus. So, to get the teachers to continue reflecting about their teaching, the research lesson, and students' thinking, the teachers were given footages of their teaching during the lesson study and selected photos of students' works and board work. This was also to encourage teachers to analyze deeper the research lesson for purposes of revision. Initially, the teachers' comments focused on how they look and the way they delivered the lesson. However, in the second meeting, the teachers

were now ready to look at the lessons more closely. The author asked them to make a list of students' misconceptions and difficulties in the lesson. This was done to focus teachers' attention on the way students think and learn. A few were identified such as the students' confusion between the representation of addition and subtraction using the concrete materials (chips), students' difficulty in accepting that it is possible to take away a bigger number from smaller number, and the students' ability to apply the method of addition to subtraction cases. When asked what may be a possible cause for these, the teachers suggested that perhaps the examples were not enough. From the author's point of view, this was not simply the case and giving more examples might only encourage rote learning (and teaching). This is perhaps an indication that the teachers needed to be given more time and opportunity to reflect about their observations.

5. Sharing of Lesson Study Results and Experience

Lesson study generates knowledge and this knowledge will be more valuable if it is shared. Asking the teachers to do a write-up will provide a context for them to reflect further on their experience and synthesize their learning. The initial plan was for teachers to prepare a report of their lesson study experiences. Sample formats and questionnaires were given to help them structure their report. However, the teachers were finding it hard to write a report of their lesson study experience. They said they were busy with teaching concerns and other activities of the school. But another reason could be that teachers are not used to writing a report. Hence, instead of a report, the teachers were encouraged to prepare a presentation, which they could share in a conference. NISMED happened to be organizing a conference during that time.

The opportunity for the teachers to share the results and their learnings lesson study proved to be a valuable experience to them. They claimed during an interview that this gave them the motivation to consolidate and synthesize what they learned since there was pressure applied – to present it to other teachers. In preparing for their presentations, the lesson study group were given the following guide questions:

a. Present the lesson especially how they developed it, the revisions they made along the way and why they made the revisions;
b. Some realizations about students, about teaching mathematics, and difficulties encountered; and
c. Plans for revising the teaching plan.

As with the 2006 model, the NISMED staff went back to the school in 2011 and then in 2012 for Cycle 2 and Cycle 3, respectively. In each of these cycles the teachers

implemented the revised lesson and started a new research lesson. In the case of the Mathematics I lesson study group, the new research lesson in Cycle 2 was about addition of integers. The group felt that the students' difficulties with subtraction had to do with their knowledge of addition. In Cycle 3, the new lesson was about introduction of integers. In Cycles 2 and 3, the entire process of the 2010 model was no longer conducted but only the lesson study process as shown in Fig. 4.

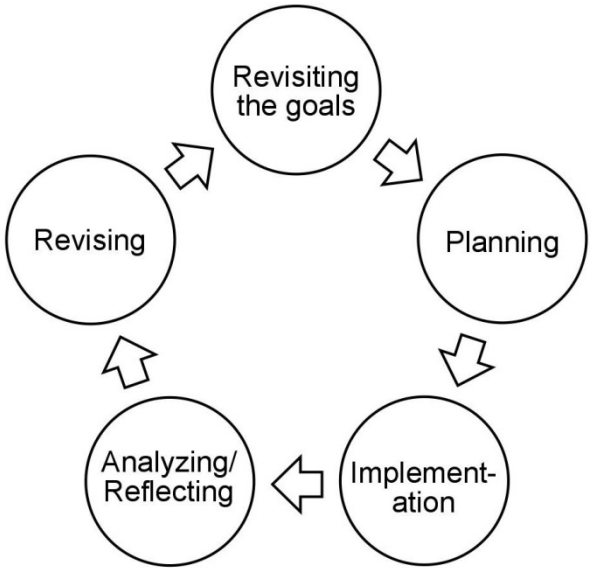

Fig. 4. The Lesson Study Process (in Cycles 2 and 3).

The author's role as facilitator in Cycle 2 decreased as the teachers gained more confidence in making their own decision. For example, no longer did the author have to facilitate the post- lesson discussion. The teachers already knew the process and what to focus on in the discussion. They also reported students' solutions and difficulties without being prompted. In Cycle 3, the facilitator's collaboration with the teachers was done through an exchange of emails. There was no need for the facilitator to be present when the teachers implemented the lesson in Cycle 3.

Teacher Learning

To gauge the impact of lesson study on teacher learning, the lesson implementation and post-lesson discussions were video or audio recorded. Interviews with teachers about what they are learning from what the study group are doing were also conducted informally after post-lesson discussions and formally at the end of lesson study cycle. Another source of data for identifying teacher learning were the teachers' presentation of their lesson study during the conference where the teachers shared their experiences in lesson study and what they learned from these experiences.

The teachers were also interviewed three weeks after the presentation of their lesson study experience in a conference. This was three months since the implementation of the research lesson. The purpose of the interview was to assess the lesson study processes and gain insights about the changes in teachers' pedagogical content knowledge. The teachers were interviewed individually. At the start of the interview, there was a brief recap of what the study group did since the beginning of the lesson study project. The author asked them which of the steps/processes they found valuable and useful to them. These processes were:

1. discussion and analysis of students responses in the assessment tasks;
2. orientation on lesson study and teaching through problem solving;
3. the lesson study process—planning, implementation, post lesson discussion, and revision;
4. reflecting on the gains, problems encountered, students' learning with the aid of video and photos taken during the implementation of the lesson; and,
5. presentation/sharing of their lesson study experience.

They were asked which step may be omitted if the same project will be done in other schools; what new knowledge they learned in the process as far as mathematics content is concerned—how to teach operation of integers specifically subtraction of integers (their research lesson) and how to teach mathematics in general. They were also asked to cite specific students difficulties and misconceptions they discovered during the course of their lesson study.

A. On knowledge for teaching subtraction of integers

This is not a complete report of the pedagogical content knowledge learned by the teachers. A complete report would entail reporting the complete analysis of the lessons in three cycles of implementation and this is not covered in this section. Cycle 3 is also yet to conclude. The teachers 'insights' and learning described below are selected to give readers an idea of the kind of knowledge the teachers were learning specific to the topic chosen for the lesson study.

The teachers shared the following realizations when they presented the result of their lesson study in the conference with regard to the knowledge of representing the content to the learner in the way they will understand them.

1. Teachers should emphasize the meaning of operation and expressions.
2. Not all subtraction phrases need to be concretized using chips because students could already do it without *the* chips; (What they meant here is the case where both minuend and subtrahend are both positive (e.g., 5 – 8 and 8 – 5) and for the case where both are negative but the subtrahend is greater (e.g., -8 – -5).
3. Pre-activities can be given as enabling prompts especially for difficult expressions like 2 – (-7); and,
4. It is best to provide each student with a set of chips.

In their research lesson, one of the representations used is the + and – chips to represent the subtraction expressions and solve them. There was only one set of chips for the whole class. On their seats, the students drew circles with + and - signs. The teachers thought that the source of students' difficulties had to do with the chips. So, the following year, in Cycle 2 of implementation of the lesson the teachers made sure that the students had their own set of chips. The teachers were quick to realize that this was not the solution to the students' application of addition to the subtraction problem. The students, after using the chips, decided to just draw the representations (see Fig. 5) than use the actual chips. The teachers realized that the source of difficulty and the scaffolding needed for the students to understand subtraction operation go deeper than simply having their own materials to work with and this was what they tried to solve in Cycle 3.

Fig. 5. Using + and – chips to do subtraction operation.

These realizations are very different from what they used to do when teaching this topic. At the start of the lesson study, teachers shared how they usually teach this topic. They said that they would just give the rules and ask the students to do many examples. They do not emphasize on giving meaning to the symbols and expressions.

In terms of knowledge of students' difficulties and misconceptions, the teachers observed that the students found it difficult to see that in -3, for example, -3 is already the number and not the number 3 with a negative sign. They also identified the structure of the subtraction phrases that students found difficult. They also realized that students' prior knowledge of a concept interfere with understanding new concepts. For example, students find it hard to accept that not all subtraction will result to a smaller difference. The revisions of the lesson in Cycle 2 and Cycle 3 were about overcoming these cognitive obstacles.

One of teachers also said that they now see the difference between "to subtract is to change the sign" and "to subtract is to add the opposite" as far as students' understanding is concerned. Although the teachers may still lack the vocabulary for describing this notion, at least they were able to recognize the difference between a discourse reflecting procedural understanding and that of one reflecting conceptual understanding (Skemp, 1986).

B. On the capability of the students

The teachers realized that the students are capable of thinking and giving reasons if they are given the time and opportunity. Initially, during the planning meeting, the teachers were apprehensive that the students may not be able to make generalizations and give reasons on their own. However, after the implementation of the lesson, they changed their positions. Here are some comments from the teachers:

> *Kung bibiyan mo pala ng* time *ang estudyante na mag-isip, makakapagbigay pala sila ng sariling* suggestion *at magkaroon ng sariling paraan kung paano mag-*subtract. (If only you will give time to students to think and to make their own suggestion, they would be able to figure out their own way on how to subtract (integers).)
>
> *Lumabas na* students can formulate their own rules*; tumatatak sa isipan nila yung kanilang na-*observe*; di tulad nung dati na binibigay ko ang* rules. (It turned out that students can formulate their own rules (on subtraction); it stuck in their mind what they observed; before, I only give them the rules.)

In Cycle 1, the teachers were more focused in getting the lesson right. In Cycles 2 and 3, they are slowly developing the habit of looking at the students' solution, difficulties, and reasoning from the point of view of the students' previous knowledge,

that is, the teachers are now becoming more aware of changes in their students' thinking.

> (After the Cycle 2 implementation) *Dati kahit nasabi na sa kanila ang* difference *ng* sign of subtraction and sign of negative *lagi pa rin nilang tinatanong kung yung* minus *na* sign *sa* expression *ay* minus *talaga o ibig sabihin* negative*; ngayon di na sila nagtatanong* after *nung* activity. *Alam na nila*. (Before, [the lesson study], even if they have been told the difference between the sign for subtraction and sign for negative, they still keep on asking if the sign in the number is minus or negative. Now, they no longer ask. They know.)

> (After Cycle 3 implementation) *Masyadong nakatatak sa kanila yung sinabi sa kanila nung* Grade 6 *sila. Kung ipa*-explain *sa kanila yung na*-observe *nila dun sa* activity*, una tina*try *nila i*-recall *yung sinabi ng* teachers *sa elementary. Di nila ito siyempre ma*-explain *ng maayos, tapos saka pa lang nila i*-explain based *dun sa* activity. (They stick to what they were told in Grade 6. When I ask them to explain they try to recall what their elementary teachers said. Of course, they could not explain it. That's the only time they will try to reason based on the activity.)

The teachers also recognized that there are concepts in mathematics that are inherently difficult. They observed that even if the students were able to make the generalizations or rules for subtracting integers by themselves, the students still had difficulty accepting their own generalization, that when they subtract, they need to add the opposite.

> *Kahit galing sa kanila na sa* subtraction you add the opposite*, parang hirap pa rin nilang tanggapin na pag-nagsu*subtract *dapat mag*-add. (Even if the students were the ones who formulated that in subtraction, you add the opposite, they still find it hard to accept that when you subtract, you should add (the opposite).)

The author also took this opportunity to open a discussion about mathematics concepts that are inherently difficult and those that run counter to students' previous experience of the concept.

C. On facilitating lessons

The teachers realized the importance of practicing wait-time especially in generating students' discussion. They said that it was not easy stopping oneself for 10 seconds before reacting to students but they were amazed by the kind of interaction it could generate. They also learned to do what they call 'poker face' so students could not read from their faces what they think about the answers given. The teachers realized that it encourages the students to think and assess answers by themselves.

In terms of organizing the class, the teachers found it better to first let the students work individually before asking them to work in groups. This way, students have something to contribute in the group discussion.

> *Dun sa* implementation *ng* lesson *dapat pala* individual *muna bago mag*-grouping, unlike *nung magturo ako,* groupings *agad, di ko nakikita na iilan lang ang gumagawa kasi*. (In implementing the lesson, I realized that it's best to let the students work individually first before asking them to work in groups right away. Unlike before, when I teach, I group them right away. I wasn't conscious that only a few of them are working.)

D. On collaboration

The teachers commented on the kind of collaboration they are doing now after the lesson study experience. Before, the extent of collaboration was only in sharing the activities they would use for the lessons. Now, their collaboration has been extended to sharing students' reactions, questions and solutions. They now asked each other what happened in the implementation. They now come together to talk about possible revisions to their lessons. This shows that lesson study can create a new culture of collaboration among teachers, a collaboration focused on researching their own teaching and student learning.

All the teachers in the lesson study group said that they used the strategies learned during the lesson study to teach the succeeding topics but went back to their old way of teaching. This shows that there is a need to find ways of sustaining teachers in their effort to improve their own teaching. In other countries like Japan, Hong Kong, and Singapore, lesson study is school wide, usually conducted in several subject areas and with full support from the principal and the Ministry of Education (as reported in World Association of Lesson Study Conferences). During both times that lesson study was introduced in Philippine schools, the most successful schools were the ones where the teachers knew

they had the support of the principal and where the head of the department worked closely with facilitators from the University.

Conclusion and Recommendation

Our country's status of education has much to gain if all teachers can have access to continuing professional development. Lesson study is one such professional development program that is available to teachers anytime they want and that directly addresses the teaching of specific topics. However, this will not be possible without the support of principals and department heads.

It was shown in the previous sections that lesson study provides a natural context for teachers to expand their repertoire of knowledge for teaching the subject matter, usually those difficult to teach, by systematic inquiry, and in collaboration with their co-teachers. Examples were given as to the kind of content knowledge for teaching the lesson study process can potentially equip the teachers with, and the culture of collaboration it can generate, which may be difficult to develop in traditional in-service training programs. However, only a few schools and teachers know what lesson study is and how to conduct such an activity or process. This indeed is the challenge.

It is the objective of this chapter that the two models used in introducing lesson study will serve as guides to would-be implementers—either as facilitator of groups of teachers doing it for the first time or as a teacher and member of a lesson study group. Of the two models, the second one is being recommended.

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