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EXPLORING LESSON STUDY AS A MEANS TO DEVELOP MATHEMATICS TEACHERS' KNOWLEDGE

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Abstract. This paper presents the results of the research on lesson study, a teacher-oriented professional development approach. The purpose of this research was to explore the progress of mathematics teachers' knowledge base when they took part in lesson study activities. Data gathered from interviews, recordings and notes of classroom observations wereanalyzed qualitatively to reach the conclusion that lesson study is a professional development method to keep enriching mathematics teachers' knowledge of content and pedagogy.

1. Introduction

Many educational researchers suppose that knowledge is one of the essential components of mathematics teachers' capacity structure because it affects their choice of mathematics tasks and the discourse that they implement in their classrooms. Profound understanding of mathematics knowledge as well as pedagogical knowledge is prerequisite for mathematics teachers to succeed in their teaching profession. The question is how these teachers can enhance their knowledge base through their teaching process. One of their choices is to participate in periodical training courses organized by educational administration agencies. However, these courses usually provide teachers with basic knowledge and skills but pay little attention to helping them integrate these knowledge and skills with their daily teaching practices (National Research Council, 2002). Whereas, lesson study, known as one of the Japanese teacher professional development forms, has been attracting international educators' attention while they seek ways to improve teachers' instruction. Numerous studies on this topic have demonstrated that lesson study activities yielded many opportunities for mathematics teachers to develop their understanding of teaching practices through the process of working in collaboration with their colleagues (Mitcheltree, 2006; Fernandez & Yoshida, 2004). However, these studies have mainly referred to teachers' professional development in general but little concentrated on progress in their knowledge when they took part in lesson study activities. Perrin-Glorian, DeBloids and Robert (2008) stressed that research concerning teachers' learning through their teaching process was scant and

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educational researchers' community had an inadequate understanding of what changed in their knowledge, especially in the domain of mathematics content knowledge and how these changes came about in their teaching practice process. Therefore, further research needs to be carried out for the purpose of learning about what has changed in mathematics teachers' knowledge base through their teaching process, especially as they implement lesson study in their teaching practices. In this paper, the researcher aimed at exploring lesson study as a means of professional development to help mathematics teachers keep enriching their knowledge of content as well as pedagogy through their teaching process.

The research method used in this study was qualitative method. Two main activities of this study were working with a group of three teachers from a high school and collecting an amount of detailed data from interviewing, recording and observing these teachers as they participated in lesson study activities. The lesson study group consisted of three high school mathematics teachers, Quy, Ba and Minh as well as a lecturer from Hue College of Education, Duyen. Names of all participants of this study should be anonymous. All the participants went through all stages of the lesson study process. After collaboratively planning the study lesson plan, one member of the lesson study group taught this lesson in his/her class while the other members observed. Following the teaching/observing stage of the lesson, the lesson study group had a session to reflect on how the lesson went and what needed to be revised in the lesson plan for next teaching. In order to examine how lesson study influenced the development of mathematics teachers' knowledge, particular lesson study processes wereimplemented on some topics in the mathematics curricula at high school's level. The lesson study process of the study lesson concerning the topic of *the inductive method* in Advanced Algebra and Analysis at grade eleven was used to illustrate progress in knowledge base of the teachers participating in this study. Data collection for this study was conducted through interviewing, recording and observing. In addition to direct observation of the teachers as they went through all the stages of the lesson study process, interviews were conducted with each of them before and after this lesson study process. The aim of the initial interviews was to learn about their previous teaching experiences regarding the study lesson whereas the final interviews was to gather information of the progress in their knowledge when they applied lesson study to their teaching practices. The data gathered from this study were analyzed qualitatively. The first phase of data analysis process involved writing memos from hearing recordings and reading notes taken in the teachers' meetings and classroom observation. These memos consisted of brief descriptions of information inferred from several portions of the recordings and the notes and were used as an initial information of learning opportunities that occurred among the teachers participating in this study. The data coding would base on these memos and be conducted by using key words such as *teaching approach, task choosing* and *teaching style*. These key words are the terms

relating to forms of teachers' knowledge for teaching. The progress in teachers' knowledge for teaching would be organized into two core categories, namely mathematics knowledge and pedagogical knowledge, and would be analyzed according to each period of this study - initial interviews, lesson study process and final interviews.

2. Research content

2.1. The relation between lesson study and the domain of mathematics teachers' knowledge for teaching

The author adopted definitions and related researches on the domain of mathematics teachers' knowledge for teaching and lesson study to develop a theoretical argument for why lesson study was considered as a professional development form to help mathematics teachers keep enriching their knowledge through their teaching practices.

2.1.1. The domains of mathematics teachers' knowledge for teaching

This study based on the domain of knowledge that mathematics teachers needed for teaching suggested by Ball, Thames and Phelps (2008). These researchers focused on describing four categories of knowledge that mathematics teachers needed in their teaching. Firstly, *common content knowledge* is defined as the mathematical knowledge and skills used in settings other than teaching. This includes the ability to recognize errors, make correct calculations and pronounce terms correctly. It is the mathematical knowledge that is required for teaching but not unique or exclusive to content knowledge characterized for teaching. Secondly, *specialized content knowledge* is the mathematical knowledge and skills that is unique to teaching. This may include the ability to recognize the nature of student errors and interpretations. This goes beyond the required procedural knowledge of math that engineers or accountants must possess to include a deeper understanding and ability to communicate that understanding to students. Thirdly, *knowledge of content and students* combines knowledge of mathematics with knowledge of students. This includes anticipating student ideas and misconceptions. It also includes interpreting students' evolvement of understanding through their mathematical language. Finally, *knowledge of content and teaching* combines knowledge of mathematics with knowledge of teaching. This knowledge concerns teachers' instructional decisions such as designing teaching plan and choosing sequencing of teaching as well as evaluating advantages and disadvantages among different representations to create an effective learning environment to help students learn mathematics more actively and creatively.

Ball's research group made a comment on the importance of mathematics teachers' content knowledge. They argued that mathematics teachers should have a deep understanding of subject matter knowledge to enable them to perform well in their teaching. According to these researchers, specialized content knowledge of teachers

needed to be both large enough to enable them to present mathematics knowledge appropriately and in different ways as well as deep enough to enable them to understand and evaluate the students' ideas to make them accurate and expand these ideas. Tzur (2010) also made a similar statement about the role of understanding of content knowledge as he conducted research on mathematics teachers' learning through their teaching practices. The author also believed that mathematics teachers should have a deep understanding of subject knowledge not merely to use but also to teach that knowledge to others. According to this author, content knowledge of mathematics teachers had to be characterized by thorough understanding of the concepts and underlying meaning of the mathematical processes to help their students grasp the nature of the mathematics knowledge.

In addition to content knowledge, mathematics teachers had to understand different categories in the domains of knowledge for teaching, namely knowledge of content and students as well as knowledge of content and teaching to teach mathematics successfully (Ball, Thames and Phelps, 2008). These two categories of knowledge, along with knowledge of content and curriculum are the three categories in the domain of pedagogical content knowledge suggested by Ball's research group. Developing a deep understanding of this domain of knowledge is one of the essentials for teachers to meet the demands of such a challenging job as teaching mathematics. That is the reason for educational researchers to go on seeking and suggesting long-term professional development forms to help mathematics teachers improve their understanding of mathematics content knowledge as well as pedagogical mathematics knowledge.

2.1.2. Lesson study

One of the professional development methods providing mathematics teachers with many opportunities to enrich their knowledge that educational researchers all over the world have been advocating is lesson study. Lesson study is a term that is directly translated from the Japanese term *jugyokenkyu*. The term *jugyokenkyu* is composed of two words: *jugyo,* which means lesson, and *kenkyu,* which means study or research. As denoted by this term, lesson study is defined as the study or examination of teaching practices (Fernandez & Yoshida, 2004). In other words, lesson study is a professional development form in which research on teaching and learning in classroom is carried out systematically and collaboratively by a group of teachers in order to improve their teaching practices. There are many different variations of lesson study process, however a lesson study process generally involves a group of teachers collaboratively designing the lesson plan, implementing and observing the lesson in the classroom, discussing and reflecting on the lesson which is taught, revising the lesson plan, and teaching the new version of the edited lesson plan. The two final stages of this process are optimal. This study, hence, followed a lesson study process including three stages of planning, teaching and observing, and discussing and reflecting.

A lesson that the lesson study group chooses to explore in the lesson study process is called a study lesson. This lesson is different from a demonstration lesson. The demonstration lesson focuses on the presentation of experienced teachers and is considered as a good example for the novices to follow. Whereas, the study lesson focuses more on how to motivate students' learning ability. This lesson may not yield outcomes as expected, but it will provide teachers with opportunities to have a deeper understanding of teaching and learning in their classes. The study lesson is also different from a lesson of observation. The lesson of observation is the lesson that every teacher must implement for other members in his/her department to observe for the purpose of after-action reviews and evaluation. Despite implementing both types of these lessons consists of the stages of lesson planning, teaching and observing, discussing and reflecting. However, the lesson plan of the observation lesson is designed by the teacher on his/her own but the study lesson is planned through the collaborative working process of the members of the lesson study group. The lesson of observation mainly aims to evaluate teachers' capacity of teaching whereas the study lesson is used to study teaching practices in order to improve their capacity of teaching.

2.1.3. Lesson study - a means to develop the domains of mathematics teachers' knowledge for teaching

Lesson study was considered as an active model of professional development because it brought teachers the key pathways to improve their teaching practices (Lewis, Perry & Hurd, 2004). Fernandez and Yoshida (2004) also pointed out that lesson study facilitated mathematics teachers to improve their understanding of subject matter knowledge as well as pedagogical knowledge through their efforts of working in collaboration with their colleagues to do researches on their teaching practices. Results from the study of Mitcheltree (2006) also showed that lesson planning, as well as discussing and reflecting on the lesson that had been taught were two stages in the lesson study process that yielded many opportunities to enable mathematics teachers to develop their understanding of content knowledge. In addition, teaching and observing the lesson was the most important stage in the lesson study process for teachers to examine how knowledge that they had just learned in the lesson planning stage was applied to the class. This could facilitate teachers to develop a more adequate understanding of content knowledge and pedagogical knowledge relating to study lessons from their colleagues' teaching experiences.

2.2. Exploring lesson study as a means to develop the domains of mathematics teachers' knowledge for teaching through practices

In this section, the author would use the data gathered from the interviews, the recordings and the notes to demonstrate the progress in the domains of mathematics teachers' knowledge for teaching while they were engaging in the lesson study activities. The content of the study lesson that was illustrated in this paper originated from

difficulties occurred in the teaching process of several teachers participating in this study. The following dialog will show what they wanted to experience in this study lesson:

Ba: One of the topics that attract my attention is the inductive method in Advanced Algebra and Analysis at grade eleven. I usually focus on guiding students to use the inductive method to solve exercises in the textbook. This makes me have difficulty responding to the students' unexpected queries.

Quy: Ba's idea reminds me of my awkward situation in teaching this topic last year. When I assigned my students to do the task "proving the equality $1^2+2^2+\cdots+n^2=\frac{n(n+1)(2n+1)}{6}$, (1)", one of my students immediately queried whether there were different ways to calculate the sum in left-hand side of the equality (1) directly. This made me feel nervous because I could not have an adequate answer at that time.

Minh: So, let choose the task "finding $S=1^2+2^2+\cdots+n^2$" to explore in this lesson.

The members of the lesson study group paid attention to exploring difficulties that arose through their teaching process. It is clear that lesson study offers many advantages in comparison with the traditional professional development methods since it can create a interactive teaching environment for teachers to overcome the difficulties in teaching promptly by discussing and sharing with their colleagues.

2.2.1. The progress in teachers' knowledge of mathematics

Results from the initial interviews show that all mathematics teachers participating in this study used the inductive method without thinking of appoaching other ways to solve the task (1). It can be recognized that the teachers' knowledge of mathematics was limited to algorithm process when they solved this task. This requires them to spend much time working together to find other solutions to the task of finding the sum *S* in order to develop a deeper understanding of the subject matters related to the topic of the inductive method. However, these teachers sought and comprehended an amount of knowledge of mathematics concerning the study lesson in the collaborative process of designing the lesson plan of this lesson:

Minh: I haven't figured out how to calculate *S* yet. Appling the inductive method to this task requires to find ways to predict the sum *S*, but how to predict this sum?

Quy: Me too, but I think we can focus on calculating a similar sum $T=1^3+2^3+\cdots+n^3$. Calculating this sum by using the strategy of finding pattern and the inductive method is easier for students to come up with answers.

Duyen: I suggest a different approach to calculate *T* directly by using the identities in form of $(1+k)^4$, $k=\overline{0,n}$. Initially, most students will choose the identities

in form of $(1+k)^3$, $k=\overline{0,n}$ because they pay attention to the terms 1^3, 2^3, ..., n^3 in this sum, but then they soon realize that these terms will be vanished when they add up these identities side by side. It is interesting that they will come across finding out the result of *S*. This leads them to use an analogous way to find *T.* Another way to find *S* is to use a visual representation model to predict this sum...

Ba: We can calculate *S* directly by using the difference method...

If the teachers had formerly focused on using the inductive method to solve the tasks in terms of proving equalities related the sums *S* and *T*, they afterwards found out other ways to calculate these sums through planning the lesson in collaboration with their colleagues. In addition, discussing and sharing their ideas of the study lesson also help them be aware of the similarity of the tasks as well as the methods to solve these tasks. It is clear that the teachers have found out different solutions to the tasks instead of the only solution used previously. Besides knowledge of the inductive method, they also paid attention to knowledge of mathematics relating to this lesson's content such as the difference method, the indeterminate coefficient method, etc. This can be seen from the reflection of a teacher after finishing the lesson study process:

Ba: Before participating in this lesson study process, I only approached tasks concerning the sums *S* and *T* in the form of proving equations. Therefore, I usually used the inductive method to solve these tasks. However, now I find out various interesting ways to calculate *T* and *S* directly such as finding a pattern, applying identities and using the difference method. This leads me to reconsider my previous teaching practices. I feel ashamed of my carelessness in the previous lessons. Experiencing in this lesson study process will remind me to think more carefully about subject matter knowledge to design lesson plans that will suit my students.

It can be regconized that lesson study created an interactive teaching environment for teachers to deepen their understanding of subject matter knowledge. Especially, this knowledge is not only common knowledge of mathematics but also specialized knowledge of mathematics that teachers learned from their colleagues' teaching experiences to enhance their understanding of subject matter knowledge to generate more effective teaching approaches.

2.2.2. The progress in teachers' knowledge of pedagogy

The author would use the data gathered to describe and analyze the progress in pedagogical knowledge of the teachers participating in this study according to three categories of teaching approach, task choosing and teaching style.

a. Teaching approach

Choosing appropriate teaching approaches for a lesson and combining these approaches effectively are two essential elements to ensure a successful teaching

practice. This is the reason why the teachers continuously try different teaching approaches to find out suitable approaches to improve the quality of their teaching practices. This is clearly shown in lesson study - a professional development method directed and conducted by the classroom teachers.

Results from the initial interviews pointed out that all the teachers participating in this study used the lecturing approach as they taught the topic of the inductive method. Despite being familiar with this teaching approach, these teachers reached a consessus within their group in trying other teaching approaches after having carefully discussed different solutions to the tasks choosen to explore in this study lesson. They agreed to choose mathematical investigation-centered teaching approach as the main teaching approach to help students develop their capacity of conducting mathematical investigation processes:

Ba: It is surprising that there are many ways to calculate *S* naturally. Before, I used to use the lecturing method when teaching the topic of the inductive method, now I think we should try to experience different teaching approaches in this lesson.

Duyen: Why don't we try to use the mathematical investigation approach? If students are formerly familiar with tasks in this topic in terms of proving assertions, we now let them find these assertions on their own.

It appears that the progress in the teachers' subject matter knowledge has led to the progress in their pedagogical knowledge. Obviously, when the teachers had a deep understanding of subject matter knowledge, they dared to change the teaching methods that they had usually used before. They themselves were aware of practical benefits of applying active teaching approaches to innovate their teaching practices without being constrained by external factors or following temporary trends. This is the most prominent advantage of lesson study that traditional professional development methods could not offer. Below is the reflection of a member of the lesson study group, the teacher taught the study lesson, upon his experiences:

Quy: My difficulties were solved easily by working in collaboration with my colleagues. In addition, I also learned much knowledge in forms of content and pedagogy from the colleagues' teaching experiences. I am so interested in using teaching approaches that I have never experienced teaching this lesson before. The combination of the mathematical investigation approach and the problem solving approach gave me a completely different experience on how students learned. If the students were formerly familiar with using the inductive method to prove a certain assertion, they now had to seek and make their predictions as well as to verify these predictions.

Results from classroom observation showed that students had to work on their own or in colaboration with their classmates actively and self-consciously to complete

tasks set by the teachers. If they formerly often acquired knowledge passively, they now have to seek and contruct new knowledge for themselves. It can be seen that changes in the teachers' approaches of teaching has led to changes in the students' methods of learning. The students innovated their methods of learning actively to meet the the demands that teachers assigned.

b. Task choosing

Choosing tasks for a practising class is not easy work. How to choose the tasks to meet the objectives of the lesson, to serve continuity and systematization as well as to be consistent with the intentions of the lesson study group is a complex problem that requires teachers to spend much time discussing. If the teachers had formerly used tasks in the textbook to conduct a practising class, when planning the study lesson they paid attention to exploiting other kinds of tasks to meet the teaching intentions of the lesson study group. They also discussed the use of the geometric number sequences to begin the lesson to help students be familiar with the strategy of finding pattern to conduct the mathematical investigation processes as learning this lesson. The procedure of task selection for this lesson is showed through the following conversation:

Duyen: We can choose a simple exercise, such as "finding the sum $1+2+\cdots+n$?" but renew it in a different form "finding the n-th term of the triagular number sequence".

Minh: There are many ways of solving this task. Which way should we focus on?

Duyen: We focus on using the properties of an arithmetic series to solve this task and extend to tasks of finding the n-th term of the square number sequence, pentagonal number sequence, etc.

Ba: The lesson will continue with the task of finding *S* then the task of finding *T*.
Quy: Students will find it easier to predict the result of *T* than *S*. In addition, as they are searching different ways to calculate *T*, the solution to calculating *S* directly will come across their mind. After that, they will explore the visual representation model to predict the result of S...

It appears that the teachers spent much time choosing the contents and the sequencing of the study lesson when they planned lesson together. They also argued and suggested various approaches to the contents of this lesson in order to be consistent with the students' ways of thinking. Results from classroom observation showed that the intended points of developing students' ability to conduct the mathematical investigation process were cared to exploit by the teacher who taught this lesson as well as were paid attention to taking notes by the other teachers. The reflections of the teachers after the lesson had finished would point out several contents in the lesson plan that needed revising to be more suitable for the next teaching:

Quy: At first, students had to spend much time figuring out the patterns in the tasks "finding the n-th term of the triagular number sequence" and "finding the n-th term of the square number sequence" but later on they were gradually familiar with recognizing patterns in the following tasks. The students had no difficulty calculating *S* directly but met an obstacle to predict this sum with visual representation model supplied. It is necessary to add the task "finding the geometric representations of n^2" to the lesson to help students be aware of two visual representation models of n^2 in terms of the square model and the triangular model.

Ba: We should use the dynamic geometry software, The Geometer's Sketchpad, to help students easily recognize the patterns of the tasks "finding the n-th term of geometric number sequences"...

2.2.3. Teaching style

Teaching mathematics is viewed as both a science and an art. If teaching mathemtaics is a science, teachers must have a steady professional knowledge base but if this work is an art, the teachers must have a little gift. Therefore, in addition to being expert in professional knowledge, the teachers have to improve their teaching styles. Many educators believed that the teachers' teaching styles are partly endowed but largely dependent on their annealing through their teaching process. Efforts of working in collaboration with their colleagues to implement teaching practices have facilliated them, especially the novices, to deepen their professional knowledge as well as to improve their teaching styles. Below is the reflection of the novice on his own experience as he participated in the lesson study activities:

Minh: I feel so lucky to participate in the lesson study group. Collaboratively planning the lesson gives me opportunities to learn detailed subject matters from rich experienced teachers as they shared their ideas of teaching particular lessons. I also learned how to apply pedagogical knowledge to teaching practices from directly observing my colleagues taught in their classes and reflected upon their practices. As a result, I am aware of many useful things of teaching that I have not experienced before, so I feel more confident in my teaching.

3. Conclusion

It can be regconized that lesson study created positive learning communities for both the teachers and the students. It provided teachers with many opportunities to reflect on their practices in a collaborative teaching environment to develop deeper understanding of mathematics knowledge and pedagogical knowledge as well as to improve their teaching styles. In addition, being active in innovating teaching approaches yielded the teachers new experience on their teaching and the students' methods of learning.

Obviously, teachers could not only attain knowledge and skills for teaching

from the theoretical aspect but also from teaching practice as they participated in the lesson study activities. By directly practicing or observing the practices of their colleagues, they could imagine what an effective teaching practice was to apply to their teaching. Lesson study is the professional development form guided by the teachers. The idea of implementating lesson study in school settings is rather simple so that every teacher can begin lesson study activities by cooperating with other teachers to continously improve the quality of their teaching practices. Because of the practical and long-term benefits as participating in these activities, in the near future, lesson study will be chosen by teachers to apply to their teaching practices to keep enriching their knowledge base as well as improving their teaching styles.

References

[1]. Ball, D.L., Thames, M.H., Phelps, G.C., *Content Knowledge for Teaching: What Makes It Special?* Journal of Teacher Education, 59(5) (2008), 389-407.

[2]. Doan, Q., Nguyen, H.D., Nguyen, X.L, Nguyen, K.M & Dang, H.T., *Advanced Algebra and Analysis 11*, Vietnamese Education Publishers, 2012.

[3]. Fernandez, C. & Yoshida, M., *Lesson study: A Japanese Approach to improving Mathematics Teaching and Learning*, Mahwah, NJ: Lawrence Erlbaum Associates, 2004.

[4]. Leikin, R. & Zazkis, R., *Learning through teaching mathematics: development of teacher' knowledge and expertise in practice*, Mathematics teacher education. Springer Vol(5), (2010), 3-21 and 49-67.

[5]. Lewis, C., Perry & Hurd, J., *A deeper look at lesson study*, Educational Leadership, 61(5), (2004), 18-22.

[6]. Mitcheltree, M. K., *Exploring lesson study as a form of professional development for enriching teacher knowledge and classroom practices*, University of New Hampshire Publisher, 2006.

[7]. National Research Council, *Studying classroom teaching as a medium for professional development*, Proceedings of a U.S - Japan Workshop. Washington, DC: National Academy Press, 2002.

[8]. Perrin-Glorian, M.-J., DeBlois, L. & Robert, A., *International handbook of mathematics teacher education. Participants in mathematics teacher education: individuals, teams, communities, and networks*, Rotterdam, The Netherlands: Sense Publishers Vol(3), (2008), 33-59.