

An Inquiry Model for Mathematics Teachers' Professional Development

Nguyen Danh Nam*

Thai Nguyen University of Education

Received 12 August 2016

Revised 06 September 2016; Accepted 22 December 2016

Abstract: This paper proposes an inquiry model for improving the teaching of mathematics based on the practice of lesson study. This model provides both pre-service and in-service mathematics teachers with multiple pathways for designing a mathematics lesson plan. The result of this research plays an important role in determining if the model is effective in helping teachers to develop their professional expertise. The model also leads to teachers' improved teaching and provides valuable insights into the process of mathematics teaching.

Keywords: Professional development, lesson study, teaching Mathematics, research lesson.

1. Introduction

Professional development is defined as activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher. The development of teachers beyond their initial training can serve a number of objectives (OECD, 1998): *to update individuals' knowledge; update individuals' skills, attitudes and approaches in light of the development of new teaching techniques; develop and apply new strategies concerning the curriculum and other aspects of teaching practice; help weaker teachers become more effective, etc.* During our empirical research, we chose lesson study as an inquiry model of teacher professional development, which helps teachers achieve the above objectives [3].

Lesson study is a direct translation for the Japanese term (*jugyoukenkyu*), which is composed of two words: *jugyo*, which means

lesson, and *kenkyu*, which means study or research. It is a system for creating professional knowledge about teaching (Hiebert, Gallimore & Stigler, 2002). Lesson study is used extensively throughout Japan and has begun to capture the attention of the Vietnamese educational community as a potential strategy for enhancing teacher professional development in Vietnam (Vu Thi Son, Nguyen Duan, 2010; Nguyen Thi Duyen, 2013) [2, 8].

Lesson study involves groups of teachers meeting regularly over a period of time to work on the design, implementation, testing, and improvement of one or several "research lessons" (Stigler & Hiebert, 1999). Research lesson (RL) is an actual classroom lesson, taught to one's own students, which is: (a) focused on a specific teacher-generated problem, goal, or vision of pedagogical practice; (b) carefully planned, usually in collaboration with one or more colleagues; (c) observed by other teachers; (d) recorded for analysis and reflection; and (e) discussed by

* Tel.: 84-979446224

Email: danhnam.nguyen@dhsptn.edu.vn

lesson study group members, other colleagues, administrators, and/or an invited commentator (Lewis & Tsuchida, 1998) [3, 4].

Lesson study is based on three following principles: a) teachers learn best from and improve their practice by seeing other teachers teach; b) teachers who have developed deep understanding of and skill in subject matter pedagogy should share their knowledge and experience with colleagues; and c) teachers should cultivate students' interest and focus on the quality of their learning. During our research, we used a model of collaborative lesson study that contains five fundamental phases (see Figure 1) [7, 9]:

i) Phase 1 (Defining RL): Choose a suitable concept, topic or lesson in the textbooks to study; identify the goals of the unit of study; map out a series of lessons that will achieve these goals; identify the key lesson in this series which then becomes the RL.

ii) Phase 2 (Planning): Plan carefully the RL in which describes students' and teachers' activities.

iii) Phase 3 (Teaching and Observing): The RL is taught by a member of the group of teachers and observed by the other members. The observing process is focused on students' thinking, behaviors and responses rather than the teacher's ability.

iv) Phase 4 (Lesson Review): Evaluate the RL and reflecting on its effect. The RL was revised and then it was taught, observed, evaluated, and reflected a second time (continue the cycle if necessary).

v) Phase 5 (Sharing the Results): Document the findings (produce a report that outlines what they have learnt with regard to the research theme and goal). The groups of teachers periodically meet together to share the revised lesson or their results on how to teach a certain concept, topic or lesson.

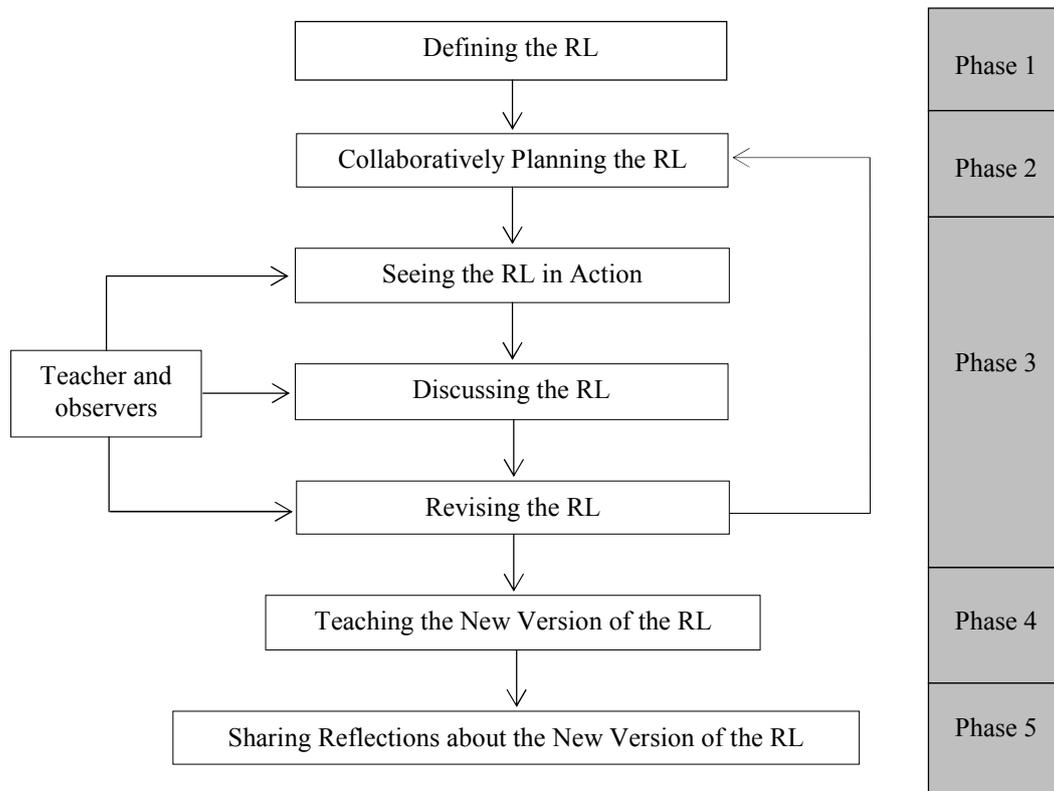


Figure 1. The Lesson Study Process in Practice.

However, there are some risks and challenges in applying lesson study in some Vietnamese schools. It was difficult for teachers of one school to be able to observe a lesson in other schools regularly, even in the same school. The lesson was then evaluated and revised for further teaching to other groups. However, the teachers did not get used to of sharing their ideas of teaching a certain lesson with others. During the lesson, in order to anticipate students' thinking and learning behaviour, the teachers need to understand students' background and learning styles but they met difficulty in observing all students as well as their time constraints. Therefore, a group of schools should create a community of teachers including online observation room so that they could share their strategies of teaching a lesson and revise it until the lesson becomes perfect.

2. Research methodology

The aim of this research is to describe the effects of the lesson study process on secondary school teachers from Bac Kan province. The research will specifically address the following research questions: (a) How do these teachers perceive lesson study as a professional development process? (b) How will engaging in lesson study affect these teachers' instructions? and (c) How does this inquiry model effect on improving teachers' teaching ability?

Groups of teachers from Ba Be District, Cho Moi District (Bac Kan Province) and researchers from Thai Nguyen University of Education (n = 45) were given the opportunity to engage in the pilot implementation and evaluation of the lesson study process. In particular, we used *inter-school lesson study* method as the complementary way of increasing the impact of lesson study by joining with neighboring schools (in both lower and upper secondary schools). For secondary school teachers, they worked in small teams to: (a) formulate a learning goal, (b) design a lesson that addresses the goal, (c) collect systematic

data about student learning and thinking, and (d) analyze the data and draw conclusions about student performance. For university researchers, they were requested to join teachers in and to contribute their knowledge and experience to analyze students' RL activity. The researchers were also expected to have accumulated deep knowledge of teaching practice through observation and participation in RL activities so that they can provide constructive well informed comments on lesson observed and the ensuing discussions (Isoda et al, 2007) [4].

Lesson study teams consist of 5-10 mathematics teachers. However, teachers from other subjects sometimes were invited to set up interdisciplinary teams (e.g. Mathematics and Physics or Mathematics and Biology) so that they could discuss about how to connect the content knowledge related to both subjects and design the interdisciplinary topics. They selected a RL that addresses academic learning goals (e.g., understanding specific concepts and subject matter) and broad goals for development of intellectual abilities, habits of mind and personal qualities. Then, they shared their previous teaching experiences of the topic, and discuss possible ways to address the lesson goals. In planning a lesson, they predict how students are likely to respond to specific questions, problems and exercises. We also invited guest observers such as school principals and researchers from universities to give supplementary comments. The observers were encouraged to focus on specific types of student activity, use rubrics to categorize or monitor student thinking or behavior during the lesson [1, 5, 7].

Video was also used as a tool not only to allow teachers who could not be physically present to see a lesson, but also to enhance the review. Video also helped inexperienced and novice teachers, who were often so traumatized by the experience of being observed that they could not remember what exactly happened in their lesson, to gain useful insights. Even experienced teachers learned from watching themselves in action.

We intended to gain an in-depth understanding of the lesson study process by using triangulation method such as teacher semi-structured interviews, questionnaires, field notes and observations. Teachers were interviewed individually after engaging in the lesson study process. Interviews were also tape recorded and transcribed. Field notes were taken during the observations of instructions.

3. A case study: teaching integration concept

Integration stems from two different problems. The first problem is to find the inverse transform of the derivative. This concept is known as finding the antiderivative. The second problem deals with areas and how to find them. This is the algebraic method of finding the integral for a function at any point on the graph.

Phase 1 (Defining the Topic). Definite integral was chosen for lesson study discussion because it is a difficult topic that related to the concept of limit. It also can be interpreted as an area. All the members of lesson study team agreed that integrals, together with derivatives, are the fundamental objects of calculus, with numerous applications in science and engineering. Therefore, the instructors should provide students with an opportunity to gain a deeper understanding of the connection between mathematics and the real world.

Phase 2 (Planning). Lesson study team found a suitable approach in teaching definite integral concept. The integral comes from not only trying to find the inverse process of taking the derivative, but trying to solve the area problem as well. Therefore, teachers could use area as a means of describing the concept or use the inverse problem of derivative concept which related to velocity. For the derivative, the motivation was to find the velocity at any point in time given the position of an object. If the velocity of an object was known at a particular time, the integral will show the object's position at that time. In other words, the derivative gave the instantaneous rate of

change, and the integral will give the total distance at any given time.

In the Vietnamese mathematics textbooks, a definite integral is defined as follows:

Given a function $f(x)$ that is continuous on an interval $[a, b]$. Suppose $F(x)$ is an antiderivative of $f(x)$ on the interval $[a, b]$. The difference $F(b) - F(a)$ is called the definite integral of $f(x)$ from a to b :

$$\int_a^b f(x)dx = F(x)\Big|_a^b = F(b) - F(a)$$

Phase 3 (Teaching and Observing). After giving the definition, teachers used 'drill and practice' strategy aimed at helping student develop calculating skill rather than applied skill and modeling competency. Observers realized that this approach of the definition did not help students understand about area problem involving integral concept. As a result, they did not know about some applications of definite integral in the real world. We can approximate the area to the x axis by increasing the number of rectangles under the curve. The area of these rectangles was calculated by multiplying length times width. After the area was calculated, the summation of the rectangles would approximate the area of the "curved trapezoid". As the number of rectangles gets larger, the better the approximation will be.

Given a function $f(x)$ that is continuous on the interval $[a, b]$. We divide the interval into n subintervals of equal width, Δx , and from each interval choose a point, x_i^ . Then the definite integral of $f(x)$ from a to b is:*

$$\int_a^b f(x)dx = \lim_{n \rightarrow \infty} \sum_{i=1}^n f(x_i^*)\Delta x$$

Phase 4 (Lesson Review). After discussion, teachers and researchers strongly agreed that the teacher can approach this definition based upon area problem. The teacher used dynamic geometry software (e.g GeoGebra) to design a situation that helps students can interact with the summation of the area by dragging and

compare the difference between uppersum and lowersum with integral as n tends to infinity (see Figure 2). After the RL, we realized that students deeply understand about infinite

integral concept. In particular, they can apply this concept to calculate the area of two-dimensional figure and solve some real world problems as well.

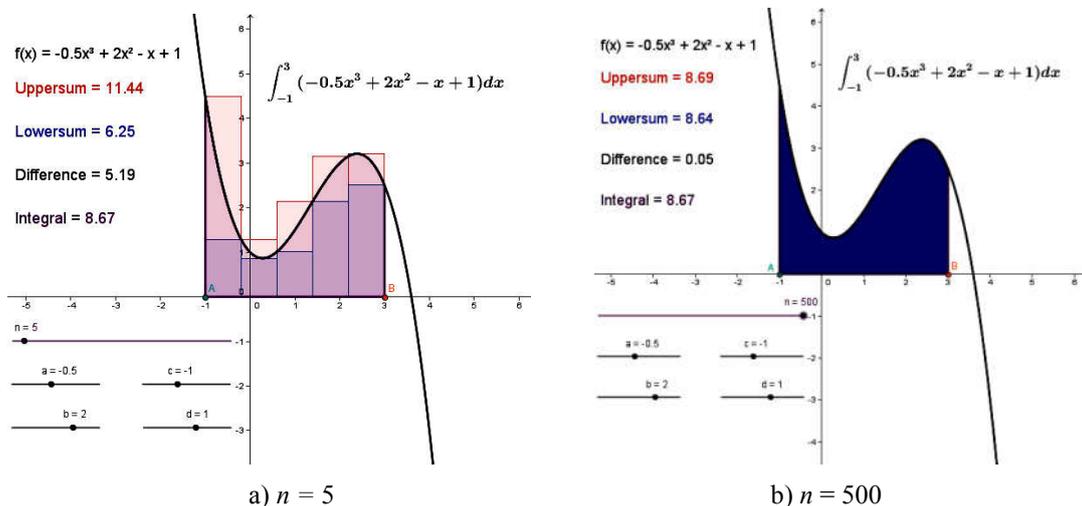


Figure 2. Approximating the summation of the area of rectangles under the curve.

Phase 5 (Sharing the Results). We shared the revised lesson plan and other teacher taught the same lesson in another class. Video was recorded as a sample lesson so that we could send it to other schools or even to teacher training universities. Students and other teachers were provided with a chance to observe and analyze the sample lesson about relating themes such as: concept approach, teaching methods, assignments, assessments, pedagogical situation control, students' engagement, students' behavior and performance, etc.

In general, the lesson study strategy allowed teachers to study particular aspects that were deliberately built into the lesson design, for example in this case the use of dynamic geometry environment for approaching the infinite integral concept and strengthening the applications of this concept in the real life.

4. Data collection and analyses

During observing RL, the focus was not *what* students learnt, but rather *how* students

learnt. In particular, our observation teams focused on students' thinking and behavior, how they construct the knowledge, how they make sense of the material, what kinds of difficulties they have, how they answer questions, how their thinking changes during the lesson and so on. Therefore, our observation teams took notes about some specific strategies that support changes in student thinking and common misconceptions that hinder students' learning.

Following the lesson implementation, the lesson study groups spent approximately one hour reflecting and critiquing the lesson. Researchers from university, who attended the implementation of the RL, acted as commentators and advisors during the discussions. The teacher who taught the RL shared teaching ideas and the observers, if needed, shared insights, posed additional questions and gave suggestions aimed at planning a new version of the lesson. After that, the teacher began working on a revised lesson plan based on what was observed and discussed. Another teacher volunteered to teach the revised lesson plan in another class (in the same term or in the following term) and other

teachers again came to observe. We used a reflection log to record what they were understanding, experiencing and learning from the process. In conclusion, teachers compiled a written report of what they had learned and presented the research lesson to the entire school and later inter-school club.

During the lesson study process, the lesson study team found that they were much more actively involved in controlling and sustaining the teaching experience. They said that “The shared instruction made a positive difference in their planning and instruction”. In the teacher interview, we also focused on personal understanding and analyzed their comments carefully. Mrs Nhan from Cho Ra Lower Secondary School shared her reflections: *“I feel more confident when I teach the revised lesson. In particular, regular collaboration with my colleagues about curriculum objectives, teacher instruction, teaching aids, ... help me learn new approaches to controlling classroom activities and instructing students”*. Mr Dien from Ba Be Upper Secondary School expressed his strongly agreement that there is a positive effect of lesson study in gaining his teaching experiences: *“I believe that the most effective place to improve teacher’s teaching experiences is in the context of a classroom lesson”*. For novice teachers like Mr Chinh and Mrs Quynh from Cho Moi Upper Secondary School, peer coaching and mediation training would improve their abilities to engage in lesson study more effectively. Receiving constructive feedback from lesson study team also played an important role in improving their pedagogical content knowledge and provided an opportunity for them to get an in-depth understanding of the content they are teaching.

In the evaluation questionnaire, teachers were asked to grade a number of factors from their collaborative working. Likert scale was used to evaluate the level of teachers’ agreement about 15 following statements with point scale from 1 (strongly disagree) to 5 (strongly agree). The mean values of these factors are summarized below:

Table 1. Lesson Study Team Questionnaire

Items	Mean
Share teachers’ previous experiences teaching a certain topic or concept	3.7
Increase and update teachers’ knowledge of subject matter	3.9
Develop teachers’ practical skills and competency	3.8
Raise teachers’ awareness of different pedagogical strategies and develops their ability to evaluate these methods in a constructive way	3.5
Motivate inter-school teachers’ collaboration	3.5
Help novice and weaker teachers become more effective	3.8
Develop and apply new teaching strategies concerning the curriculum	4.0
Develop deep understanding of and skill in subject matter pedagogy	4.0
Positive effect on students’ learning styles	3.2
Develop the habits of mind for better preparation the lesson plan	3.6
Meet the students’ learning pace and goal	4.1
Reflecting and critiquing lessons and textbooks	4.2
Develop teachers’ critical thinking	4.4
Understand students’ thinking and behavior	4.2
Meet the inter-subject requirements	4.3

In a survey of 45 active lesson study practitioners in Bac Kan province, 93% reported that lesson study helped them improve their teaching and 95% believe that lesson study is the most effective form of professional development. Data from Table 1 shows that this model helps teachers learn about teaching with technology by observing each other and discussing the lessons. Moreover, lesson study also helps teachers get more understanding about subject curriculum development. During the discussion, teachers have a chance to perceive the knowledge of how mathematical topics are related across grade levels, how student understanding is built up, kinds of representations and

manipulatives that support students' learning, students' state of prior learning, common misconceptions, and how various teaching strategies contribute to learning.

In our research, we have also examined how students learnt as well as their attitudes in a revised lesson. Fifty five students ($n = 52$) were asked to score a number of items in Table 2. Likert scale was used to evaluate the level of students' agreement about 7 following statements with point scale from 1 (strongly disagree) to 5 (strongly agree). The mean values of these items are summarized below:

Table 2. Students' Attitudes towards in a Revised Lesson

Items	Mean
Students were carried out more activities with practical situations	4.2
The teachers' questions during the lesson were very easy to understand	4.0
Students had more opportunity to interact with the teacher and other students	3.5
Students could work with small group or pairwork in a flexible context	4.1
Students knew how to apply information technology in representing mathematical models	3.1
Students understood about the nature of definite integral concept	3.4
Students understood the application of definite integral in the real life	4.3

The results have shown that in a revised lesson, students carried out more activities and worked in a collaborative environment. Teacher's questions were easy to understand because the teacher had prepared the questions very carefully. As a result, there were a lot of students who understood the definite integral concept as well as its application in the real life. The effectiveness of this lesson stems from lesson study approach in which the teacher and her/his colleagues designed the lesson together and revised it right after their teaching.

5. Discussion

The purpose of this paper has been to discuss the use of lesson study model for professional development in secondary schools. Results revealed from the data clearly indicate that this model can serve as a means of teacher professional development with positive impact on teacher instructional practice. A long-term approach for groups of teachers to work together and to improve student learning in their school and inter-schools as well.

Lesson plan should be constructed by the group from different schools rather than on the individual teacher. For mathematics teachers, possible focus for lesson study model would be: Lesson preparation; resources and activities; use of information and communications technology; students on task; paired work; teacher praise; explanations; contexts and applications; functional mathematics; questioning techniques; reviewing answers; challenge and extension work; lower attaining students; notation, layout, language, precision; pace of activities; use of teaching assistants; homework; monitoring of student progress; time management; assessment. As a result, there is a continued need for further implementation and future research on the lesson study model aimed at providing teachers with an inquiry model to improve their teaching ability and professional development so that they can meet the requirement of educational reform in the next few years.

References

- [1] William Cerbin, Bryan Kopp (2006). Lesson Study as a Model for Building Pedagogical Knowledge and Improving Teaching. *International Journal of Teaching and Learning in Higher Education*, 18(3), 250-257.
- [2] Nguyễn Thị Duyên (2013). Nghiên cứu bài học - Một mô hình phát triển năng lực dạy học của giáo viên Toán. *Tạp chí Khoa học, Trường Đại học Sư phạm Hà Nội*, 58, 74-84.
- [3] Clea Fernandez, Makoto Yoshida (2004). Lesson Study - A Japanese Approach to Improving

- Mathematics Teaching and Learning. Lawrence Erlbaum Associates Publishers.
- [4] Masami Isoda, Max Stephens, Yutaka Ohara, Takeshi Miyakawa (2007). Japanese Lesson Study in Mathematics - Its impact, Diversity and Potential for Educational Improvement. World Scientific Publishing.
- [5] Maitree Inprasitha (2011). One Feature of Adaptive Lesson Study in Thailand: Designing a Learning Unit. *Journal of Science and Mathematics Education in Southeast Asia*, 34(1), 47-66.
- [6] Robyn Pierce, Kaye Stacey (2011). Lesson Study for Professional Development and Research. *Journal of Science and Mathematics Education in Southeast Asia*, 34(1), 26-46.
- [7] Lynn C. Hart, Alice Alston, Aki Murata (2011). *Lesson Study Research and Practice in Mathematics Education - Learning Together*. Springer.
- [8] Vũ Thị Sơn, Nguyễn Duân (2010). Nghiên cứu bài học - Một cách tiếp cận phát triển năng lực nghề nghiệp của giáo viên, *Tạp chí Khoa học Giáo dục*, 52, 45-48.
- [9] Akihiko Takahashi, Tad Watanabe, Makoto Yoshida (2006). Developing Good Mathematics Teaching Practice through Lesson Study: An US Perspective. *Tsukuba Journal of Educational Study in Mathematics*, 25, 197-204.