Chapter 2

Related Literature Review

In conducting the research for science teaching professional development on instructional provision to enhance scientific thinking skills of Mathayom Suksa 3 studentsm, there are related documents and researches as in the following topics:

2.1 Teaching profession development

2.2 Lesson study

2.3 Scientific thinking

2.4 Organizing science learning process through inquiry method

2.5 Related researches

2.1 Teaching Profession Development

To study on teaching profession development in this research, the researcher had studied on the concepts and models for teaching profession development the details of which area as follows:

Concept of Teaching Profession Development

According to the Teacher Council's 2005 law on professional standards and ethics published in the *Royal Thai Government Gazette*, volume 122, special section on 76 – d. pages 39 and 43 provides the professional definition and operational standards as follows.

"**Profession**" is referred to the educational profession to mainly function on the instruction and promotion of the learner's learning through various methods as well as the responsibilities concerning administration of the schools at pre-school, basic education, and pre-degree higher education both by the state and private sectors and the administration beyond the school at the educational service areas including the support for or other operation related to the provision of education or other operations related to

the instruction, supervision, and educational administration in various educational agencies and organizations.

"Teacher" is referred to the person who maintains the main profession on providing instruction and promoting learning of the learners through various approaches in the pre-school, basic education, and pre-degree education in the state and private institutions.

From the literatures reviewed above, it could be concluded that the one who maintained teaching profession had to carry out the main mission on instruction and the promotion on learning of the learners through various methods and had to comply to the operational standards as follows:

1) Continuously carrying out the academic activities concerning the teaching profession development
2) Making decision on doing the activities for the best outcomes for the learners
3) Being determined to develop the learners to their full capacity
4) Developing the instructional plans to assure their best effectiveness.
5) Developing the instructional media to assure an effective instruction
6) Organizing the instruction focusing on long-term effect on the learners
7) Reporting the results of the development on the quality of the learners in a systematic way
8) Serving themselves the good model for the learners
9) Collaborating with others in the educational institutions on constructive basis
10) Collaborating with the community in a constructive way
11) Searching for and use the information in the development process
12) Building up opportunities for the learners to learn in every situation

From the definitions of and standards on the operation of the teaching profession maintainers, it was necessary that the teachers have to comply to the professional standards and had to continuously develop the teaching profession as the

profession was dynamic and there had been new knowledge constantly added up to the old one.

For the meaning of teaching profession development, many academics had provided explanations as follows:

Gusky (2000, cited in Wisalaporn, Sermsak, 2002:48) who had stated that the teaching profession development was referred to the processes and activities designed to promote the educator's knowledge, skills, and attitude toward the profession to be used to improve learning of the students.

U.S. Department of Education (2004:1 8) stated that the professional development was the set of activities including the followings:

1) The improvement and enhancement of the teachers concerning the subjects taught by the teachers and increase chance for the teachers to be acceptable on their teaching competence.

2) The integration of the plans to improve education of the school and higher level agencies.

3) The provision of knowledge and skills to the teachers, the principal, and administrator to assure the student's opportunity to acquire the standardized academic contents and the achievement along the set standard.

4) The improvement of the skills on managing the classroom.

5) Emphasis or focus on the sustainably quality classroom, and the speeding up to positively affect the instruction and not limited only to the one day seminar or short–term workshops or conferences.

6) The support for selecting, recruiting and training the teachers of high quality as well as those who were about to be accepted as the one with quality.

7) Facilitating the teachers to gain more understanding on the effective instructional strategies.

8) Complying to various standards.

9) The development was collaborative effort of the teachers, the principal, parents, and administrators.

10) It was designed for the teachers who had to teach the students who had constraint on English.

11) For training the teachers and the principal on using technology to assure the teacher's ability to use the technology the instructional development.

12) For evaluating the impact on enhancing the capacity of the teachers and upgrading the academic achievement of the students. The results of the evaluation would be used to improve the quality of the teaching profession development.

13) Proposing the method of teaching the students with impairment.

14) Presenting the guideline for instruction basing on the information and the evaluation.

15) Proposing the instructional guideline by which the teachers, the principal, and other educational personnel could work together with the parents of the students in higher extent.

Thus the teaching profession development had to be studied both in its model and method to use as the guideline for development to comply to the Teacher Council's bylaws and context of the implementers to assure the best benefits.

Model of Teaching Profession Development

The 1999 Education Act and the 2nd Amendment in 2002, in Article 52 had required the system of the production and development of the teachers, faculty members, and educational personnel to have the quality and standard justifying being the highly developed profession to assure the effectiveness in providing instruction. Many had proposed the models for teaching profession development as follows:

Sarrattana, Worot (2001: 195-196) had proposed the five models for teaching profession development as follows:

1) The development initiated from the need of the teachers themselves – This was started by the teachers who set up the needs and necessity of their self-development. This type of development was the best and could directly relate to the teacher's direct learning experience.

2) The observation and the evaluation could provide the opportunity for the teachers to observe and provide feedback to other colleagues.

3) The participation in the development process could start from the problem identification, information collection, carrying out the operation, and evaluation whose result could be used for further development.

4) The training – This model had long been used. If focused on transmitting knowledge from the resource person to the trainees.

5) Problem-solving or conducting classroom research.

Moreover, Phonsrithong, Polsan (2003: 1-5) had proposed the model for teacher development as follows:

1) Adjusting the paradigm of the concerned individuals in all parts of the process to build up mutual understanding and collective effort to achieve the set goal.

2) Using the participatory learning process which included participatory effort, participatory thinking, participatory acting, participatory lesson concluding, and participatory getting the results.

3) Using school as the base for developing the teachers and other educational personnel.

4) Mobilizing resources from every sector to contribute the process of teacher development.

5) Using the success of the teachers as the indicator for salary or position raisings and further evaluating to qualify the professional license of the teachers, to glorify, and to award.

Keesokpun, Benjawan (2008 : 112-116) had synthesized the models of teacher development popularly used in Thailand and came up with 13 models as follows:

1) Orientation - This was the process to refer to the advices provided to the new personnel of the organization to be informed about all kinds of information on the organization such as the history of organization, policy, and function, conditions, employment, wage and salary, administrative persons, colleagues, and working conditions.

2) Training - It was the process to refer to the procedures to enhance knowledge, expertise, and experience to enable all personnel in a certain organization

or agency to better perform his or her responsibility leading to the productivity or the achievement of the organization's goals.

3) Workshop - This was the process referring to the meeting organized for the participants to study on a certain problem and collaboratively take action to derive the expected outcomes. There were meetings and consultation to collectively solve the problem on practical basis among the ones who had experience on the job and were interested to collaboratively solve the problem.

4) Seminar – This process was the meeting to examine and discuss on a certain issue or topic set. All the participants would help assign a certain individual to lead the seminar to assure it was carried out within a certain scope. The seminar focused on exchanging ideas, questioning on certain unresolved issues, and provided more perspectives to assure the validity of the issues under consideration more than simply quarreling on the issue or question which could be the general one interested to all and could benefit the operation to come.

5) Publication – This process was to diffuse the information and academic points to personnel of the organization which might come up in academic form benefiting the operation of the personnel in organization, such as newsletter. This was a way to keep the personnel more knowledgeable on the operation leading to more effectiveness of the operation. The publication could indirectly provide knowledge to personnel encouraging them spend their available time in a useful way. It also helped keep the personnel informed about interesting things benefiting the personnel and organization.

6) Academic Events – This process was the activities organized to enhance the personnel's knowledge in certain period. It also helped encourage the personnel to develop themselves to keep up with the academic progress. There could be many activities organized for the event such as academic exhibition, lecture delivered by knowledgeable persons, panel discussion by experts in the field, distribution of academic documents, showing video on certain academic issue, competition on academic contest, for example.

7) Study Tour – The process was referred to the organization's support for its personnel go to and observe the operation carried out in other organizations in

form of what was known as study tour/visit. This kind of activities would remind the personnel not to misconceive that what they had done was the best as they had no chance to see other things to compare with. The observation on the activities carried out by other organizations would provide opportunity for the individuals to compare and get some idea and example of conducting similar operation as well as some problems or obstacles and how they had been resolved in such organization. All of these lessons learned could be applied in their own organizations as well.

8) Supervision – The process was referred to the activities organized to provide opportunity for the teachers to acquire knowledge and information to reflect and top up on the lessons they had learned through their real operation. This reflection would become an important factor for an individual to modified their thinking system, value, and behavior of the person.

9) Further study – This is the process of supporting the personnel to have the opportunity to continue their education. It is an important method of the modern personnel development process particularly, for personnel who had performed their direct responsibility to educate "people" who were the most important resource to become the human resource to bring about the economic, social, and political progresses to the country.

10) Job training – This was the a model of teaching profession development that could help the teachers to understand and perform the task in an easier, more convenient, and faster ways. The chief would be the one who would teach the job his/her subordinates. The process should come up with the task areas with the list of things needed to be known and operated. The new comers should obtain all and the complete set of information and try it out by themselves. The trainer should be prepared in two aspects – the content preparation and the instructional equipment and place.

11) Academic promotion and development – This was referred to the promotion to assure the progress for the teachers who would have to gain creativity and initiative in using the new innovations to develop the instruction and could also use the constructed academic work to submit for being evaluated to move upper on the position and salary lines adding up to their motivation and morality to continue to perform well on the job. As the academic works were the documents related to the instruction could

reflect the person's expertise. The improvement of the education's quality had to be done along the improvement of the teacher's quality.

12) Job rotation – This was the process well relevant to the teaching profession development. It could open for the teachers to be well around in the job and could learn new things and had wider perspective on the profession.

13) School-based teaching profession development – This process carried out the teacher development basing on the school's context starting at the school's and instructional changes of the teachers. The teacher development was done for the whole team of the school's teachers focusing on collaboration in which the organization's personnel had perceived, understood, and operated the work together.

From all these literature reviews on the teaching profession development, it could be concluded that there were many models of teaching profession development. One could develop them by him/herself or through the research conducted by the whole team of teacher. The researcher through this collective approach, the teaching profession development could be more effective and sustainable. It is the development stemmed from the needs of the teachers through the development basing on the school. It could also be regarded the school-based teaching profession development. Through the process, the teachers could gain knowledge, competence, and attitude change on certain issue to assure the change and development along the same direction satisfying the needs and relevant to the context of the school. The process would be collectively worked out together under the supervision of the administrators, superintendents, or all the concerned sides leading to the instructional development to effectively achieve the goals set. There should then be the teaching profession development process that helped the teachers to develop themselves and encourage them to learn along the student's learning. The process required the cooperation within the school. The lesson study then is an innovation that could help facilitate the teaching profession development and it could be used for the school-based development leading the sustainable teaching profession development relevant to the needs and context of the school.

2.2 Lesson Study

Definition of the Lesson Study

The lesson study was originated from the effort to develop elementary education instruction in Japan (Hiebert, 2002). In Japan, the term *Jugtou-Kenkyu* has been used. The term *Jugtou* was referred to the lesson. The term *kenkyu* meant the study or research. The process was the way to achieve the teaching profession development with a goal differing from other teaching profession development methods. This was the collaboration among the teachers to improve the instruction of the teachers and, meanwhile, develop the learning onto the students (Isoda. 2007:8-15).

Lewis (2002) had discussed about the lesson study which could be concluded that the lesson study was a guideline for the teachers to cooperatively work together to study the instructional content, method of solving the problems, and methods to assure the understanding on part of the students. This observation was similar to that made by Takahashi & Yoshida . (2004: 437) who stated that " The lesson study is the collaboration among the teachers in presenting ideas about the instructional planning, instructional media using, the participatory effort to observe the instruction of the teachers in the real classroom. The approach also provided the guideline for working together utilizing the analysis, criticism, discussion, and learning exchanges all of which could lead to the improvement of the lesson and the development of the instruction." Later, Sotirhos (2005:8) had stated that "The lesson study is referred to the method in developing the profession basing on the effort to improve from within." Similarly, Wang (2006:6) had contended that "The lesson study is the model of long-term professional learning of the teachers who could use it to develop themselves. Together, the teachers would systematically carry out a research and lend hands on the instruction and learning in the classroom aiming at promoting good learning experience on part the students and improving the instruction of the teacher her/himself."

In this research, the lesson study has been used to specifically mean the science teaching professional development on learning provision through which the administrator and the teachers would participate in setting up the learning plans, implementing them, observing the class, reflect, and conclude the effect of the learning provision to further improve the learning and guideline for instructional development to assure their sustainability.

Model of Lesson Study

The lesson study was a collaborative effort of a group of teachers in achieving the long-term goal for the students to assure their achievement of the learning goals and ability to apply them in their real life. There were many writers who had proposed the model and procedural steps of the lesson study as follows:

Lewis (2002b) had introduced the procedural step of the lesson study coming up with 4 cyclical steps of lesson study as follows:

(1) Setting up the goal for the students to have knowledge, understanding, and the long-term development and cooperation to set up and design the lesson for the research to lead to the learning achievement in the real life.

(2) Implementing the lesson by the teacher with other teachers to join in as observers and help collect the effect on the learning and development of the students.

(3) Discussing the issues occurred through the observation during the implementation of the lesson and using them to improve the lesson and teaching of the teachers.

(4) Use the improved lesson in the other classrooms' teaching. If necessary, there could be a research for the improvement of the lesson, if possible. All these steps would be in cyclical loop known as the lesson study cycle as shown in Chart 2.1below.

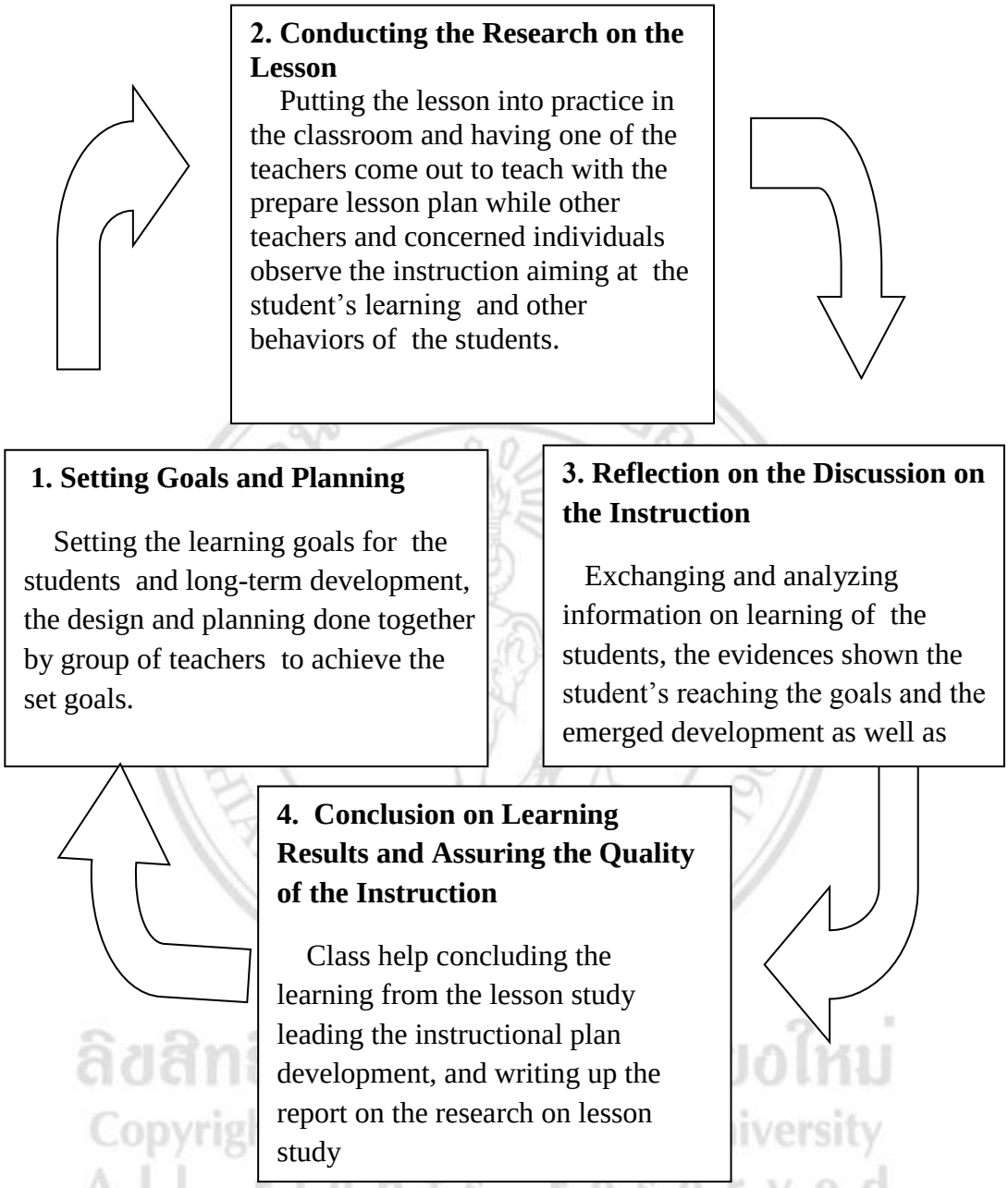

Chart 2.1 Cycle of Lesson Study Along the Concept Suggested by Lewis (2002)

Murata and Takahashi (2002) and Stepanek (2007:14) had described the process of the lesson study the teachers worked together on the following 5 steps of lesson study cycle.

1. Setting up the long-germ goals of lesson study

2. Planning the instruction aiming at developing the students toward learning through the practice

3. Carrying out the instruction along the plan and observing the instruction actually occurred in the classroom, discussing and reflecting aiming at analyzing the thinking and learning competence of the students

4. Improving the instructional plan and the instruction basing on the information collected and carrying out the instruction along the improved plan for one more time in the real class

5. Reflecting on and exchanging learning among one another through the cycle of the lesson study as in figure 2.2.

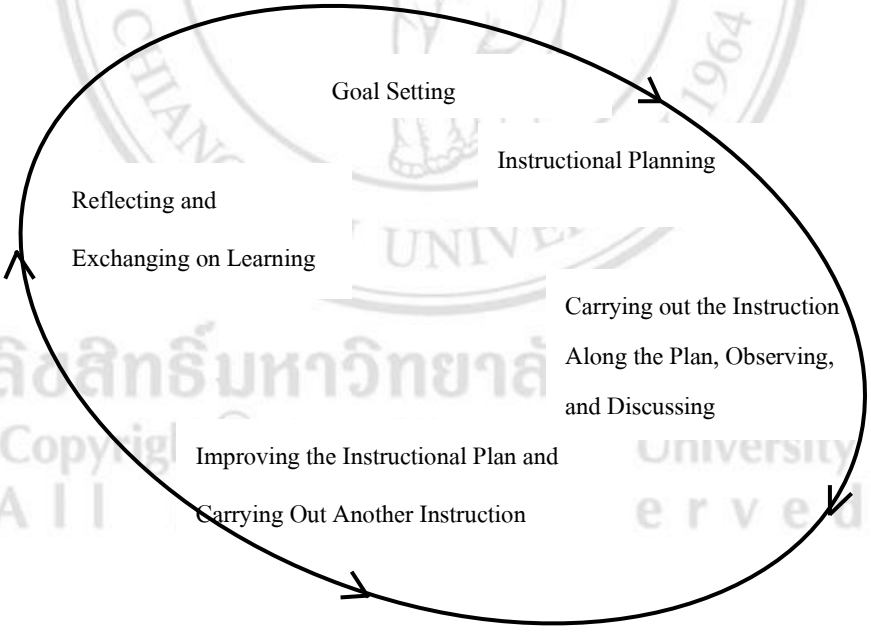

Figure 2.2 Cycle of Lesson Study Proposed by Stepanek (2007:14)

Stigler and Hiebert (1999 : 112-115) had suggested the procedural steps for teaching profession development using lesson study in 8 steps as follows:

Step 1 - Defining the problem Lesson study: This was the system emphasizing the problem solving process beginning with the problem identification to stimulate the motivation and operational framework setting of the group of teachers. The problem could begin with that which was general (How to make the students interested in mathematics?) or a more specific issue (How to develop understanding of the students on the addition of the fractions with different denominators?). Normally, the teachers would pick up the problems from their classroom teaching experience affecting learning of the students or the problems concerning policy of the superior or national level agencies.

Step2 - Planning the Lesson: When the instructional goals had been set or chosen by group of the teachers. They could meet to consult and discuss how to set the instructional plan and the goals of such planning to not only obtain the effective learning plans but also to develop knowledge and understanding on the instructional planning. The plans set initially would be presented in the forum of teachers at the school level to get the wide and various reflections and feedbacks to benefit the furthering development. This step of planning might need a month or so to come up with the plans feasible in using in the real class.

Step3 - Teaching the Lesson: The step was to implement the plans organized together in the classroom for the actual instruction whose time and duration would be set to fit all the teachers' working plan. The teacher who actually taught would be the one who had part in setting up the plan for every step. When he or she was actually teaching, the rest of the teachers would observe and noted down the variety of information and observations in details to serve as the information for reflecting on the lesson in the step to come.

Step4 –Reflecting on the Lesson's Effect and Evaluating the Lesson: After the end of the instruction, the teachers would evaluate and reflect on the lesson. Normally, the teacher who taught would be the one who express ideas and reflect his/her instruction for the first one by focusing on evaluating if and how much the instructional activities were successful, if there was any success and to what extent, and if there were any problems or obstacles to not to achieve the objectives set in the plan. Besides, the reflections made by other members of the group which would focus on the lessons collectively planned and not on the teacher who had put the plan into practice in

the classroom. Every member of the group would be mutually responsible for the outcomes of the instructional plan. The criticism was on his or her outcome to lead to a better improvement or more effectiveness.

Step 5 -Revising the Lesson: This was the step to revise the lesson of the group's teachers . The improvement on the lesson would be based on the information obtained from observation and reflection on the lesson which might relate to the adjustment of the instructional media, instructional activities, the problems presented in the lesson, questions used at each of the steps, etc. More often than not that the improvement of the lesson was due to misunderstanding of the students evidently observed during carrying out the instruction.

Step6 - Teaching the Revised Lesson: After the instructional plan revision, the plans would be used in the class for one more time either by the same teacher or another teacher in the group. In this instruction, the teachers of the whole school would be invited to come and observe.

Step7 - Reflecting and Evaluating: This was to reflect and evaluate the operation on the lesson development by all members of the teachers in the and there could be some experts from external sectors to join in the reflection as did in the previous step. The teacher who taught would get the opportunity to be reflected on his/her instruction. The reflection on the lesson would assure the learner's learning and understanding on the lesson. At the same time, the reflection could be done on other problems related to the design of the lesson both in theory which included the principles for the design as well as other sets of learning gained from the instruction, lesson planning, and lesson implementation in the classroom.

Step8 - Sharing the Results: Though the research was the case study on a case on the lesson, the basic education curriculum of Japan was the same over the country. The findings or study results could be useful for the teachers all over the country who taught the same subject and at the same level. Consequently, there had been the supports for publicizing the results of the study in terms of document and presentation to the annual meeting or seminar at the national and provincial levels.

Basing on the steps of the study done by Stigler and Hiebert as shown above, Baba. (2007:3) had proposed the process lesson study composing 3 phases – lesson

planning, implementing the lesson plans, and reflecting on the operation. The 8 steps of lesson study could be operate in these 3 phases as shown in Chart 2.3 below.

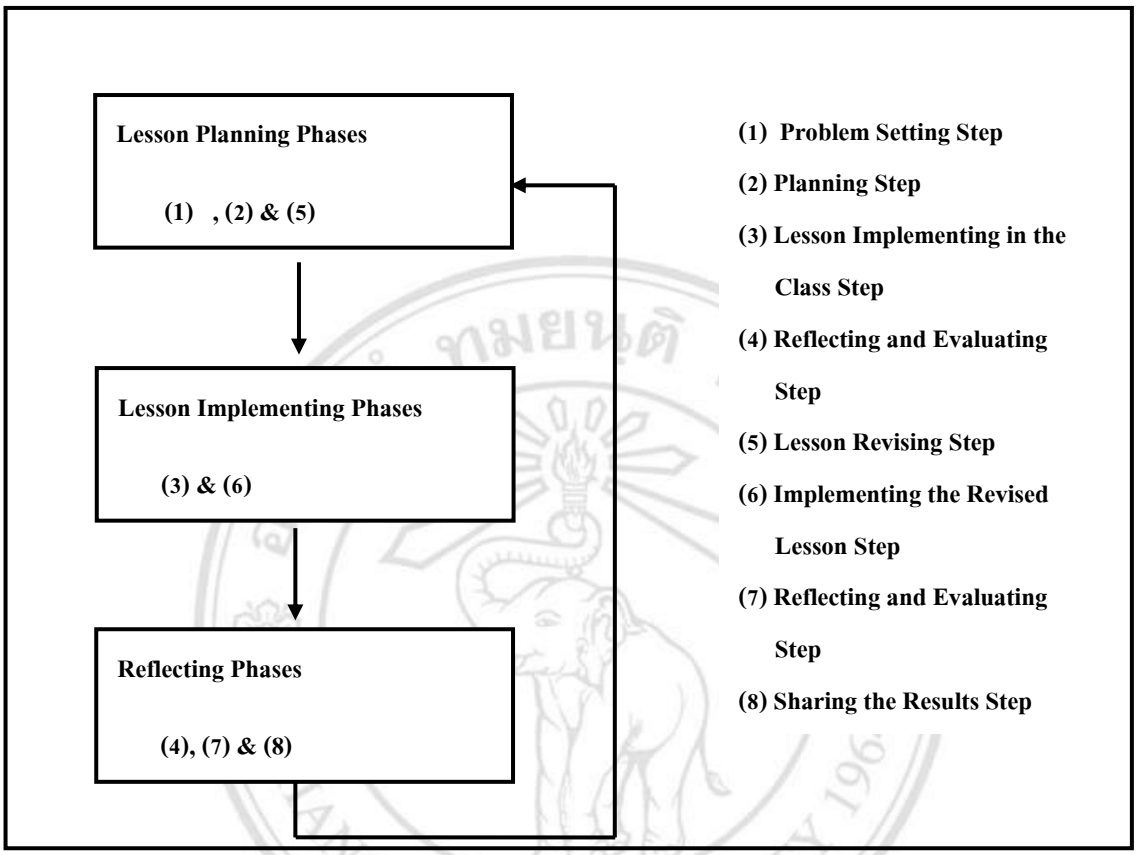

Chart 2.3 Process of Lesson Study Proposed by Baba (2007)

For the lesson study in Thailand, Inprasit, Maitree (2007) has proposed the 3maine steps of lesson study as follows:

Step1 - Mutual Planning Among the Researchers, Research Assistants, and the Research-participating Teachers

Step2 – **Mutual Observation on the Teaching**: The mutual observation was done in the real implementation of the lesson in the classroom by the teacher, team of researchers, and the other teachers aiming at observing the thinking process of the students not on the teacher's teaching competency.

Step3 – Mutual Reflection on the Lesson to be used in revising the lessons to be used for one more time in the classroom

From the concepts and models of lesson study mentioned above, it could be concluded that the lesson study had to be operated in cyclical steps continuously and could be used from science teaching professional development suiting the context and needs of the school's development. Thus, in this research, the administrators and teachers had to mutually pursued the activities along the 3 steps of the lesson study as follows:

Step 1 –Planning the Learning Organization. It was the process in which the teachers collectively analyzed the indicators of learning on science subject and the goals of developing scientific thinking skills of the students. The teachers would work together in planning for providing learning to be used in setting up the learning activities to achieve the set goals.

Step 2 –Implementing the Learning Organization Plans and Classroom Observing. The process included putting the lesson into practice in the classroom carried out by one of the teacher team using the plans set while other teachers and the concerned persons observed the instruction and collected information aiming at the student's learning, participating, and other behaviors.

Step 3 – Reflecting and Concluding the Learning Provision: This was the step in which the teachers could collectively share and analyze the information on the learning behavior of the learners and worked together in concluding the learning gained from applying the lesson study leading to the improvement of the instructional plans as well as the instructional methods.

2.3 Scientific Thinking Skills

This study on scientific thinking had many issued concerned such as the meaning and contents of scientific thinking including the procedural steps and components of scientific thinking.

Meaning of Scientific Thinking

Scientific thinking is the systematic way of thinking which methods more inclusive and concise than the thinking in general (Ruby, 1968 : 207). The definition was similar to that proposed by Dickman (1996: 1) who stated that scientific thinking differed from the common sense a it had used logic in describing the issues on nature,

the report from one's experience, and the direct observation leading to new knowledge which was more objective and changeable. Likewise, Dunbar (1999:730) had concluded that scientific thinking included the process of thinking in science which included the problem identification, theory forming, experiment design, hypothesis testing, interpretation of information, and discovering in science. Similarly, Azmitia and Crowley (2001: n.d.) had stated that scientific thinking was concerned with the use of reasoning, experimenting, and hypothesis testing. Likewise, the Office of National Education Commission, and The Thailand Research Fund Office (1998: 9-11) had contended that the scientific thinking was the thinking that was reasonable having ways of checking the reliability of the information source and proving the validity using empirical evidence.

From the analysis on the meanings of scientific thinking mentioned above, it could be concluded that scientific thinking was referred to the thinking the individual used in searching for knowledge and discover the answer for various problems, particularly when concerning natural objects by using empirical evidences to serve as the base for the thinking to assure the acquisition on the most valid and reliable answers.

Steps of Scientific Thinking

There are details in each step of the scientific thinking as follows:

1) Thinking for Identifying the Problem

Thinking for identifying problem was the thinking starting from cautiously analyzing the problem and the issues by separating out the non-relevant issues, differentiating between the facts and opinion, and setting up basic assumptions on the situation by having the learners to observe things surrounding the individual or in the classroom and trying to find how such things had happened or come to exist and why, identifying factors or conditions or situation of the problem as well as collecting the information relating to such problem, and coming up with the title of the problem with short and meaningful phrase (Beyer, K.B. 1997; Landsberger, J. , 2004). The authors had come up with the 5 steps of thinking to identify the problem as follows:

1. Carefully and concisely examining the basic information on the situation with open heart.

2. Examining the information to differentiate fact and opinion

3. Identifying the issue unsupported by the facts or the issue that was without sufficient explanation leading to the doubt.

4. Ordering and selecting the significant and out-standing doubts.

5. Adjusting such doubts to be the short, concise, and clear statements

Thus the thinking for identifying the problem was the thinking occurred after the students had examined the basic information or situation and analyzed and selected the significant or issues to clearly identify the problem.

2) Thinking for Setting Up the Hypotheses

The setting up the hypotheses was concerned with feasible identifying the factors or variables possibly causing the problem by compiling the facts related to the problems and carefully coming up with the answer in cautious way using such facts and explaining the impact of the factors causing the problem (Koning, R. E.,1994; Bandam, L. E. and Bandman, E. , 1995). This was an anticipation of the answers which could be validated using knowledge and observation on the problems previous experience. In anticipating the answers and choosing the best ones for the problem (Schafersman, B. S., 1997; Landsberger, J. ,2004).

Concerning the way for thinking about the hypothesis setting, there were 3 ways of doing so as follows:

1. Anticipating the answer from the issues possibly causing the problems

2. Selecting the answers that were mostly the causes of the problems and could be validated

3. Adjusting the answer anticipated to make it shorter, concise, and clear.

Thus the thinking for setting up the hypothesis was the thinking that could emerge after the students had clearly identified the problem and collected the facts concerning the problem to guide the anticipation of the answers to problem by choosing the clear answer and the one that could be validated.

3) Thinking for the Hypothesis Testing

The hypothesis was an operation to find the answer. There were many ways to do it beginning from observation to the concise experimentation (Bandman and Bandman, 1995, and Orpheum Children Science Museum, n.d.). One had to identify the issues to be enquired, the factors that could be measurable and compared, identifying the control and comparing variables, method of measuring, or valid observing methods. Generally, the method mostly used to test the hypothesis was the experimentation (University of Utah, 1997 – 2002). There were 5 main steps of thinking concerning hypothesis testing as follows:

1. Examining the hypothesis and related variables.

2. Identifying the variables which could be measured and compared

3. Selecting the variables to be studied; if hypothesis testing was to be done by experimentation, identifying the independent variables, the dependent, and the control ones.

4. Identifying the method and procedural steps of the hypothesis testing, and variable measuring and observing.

5. Recording the result of the study using the recording model that was relevant to the information to be acquired.

The thinking for hypothesis testing was the thinking after the students had clear hypothesis, identified the variables which were measurable, designing the method and procedural steps for testing the hypothesis and setting up the model for recording the results in relation to the information to be acquired.

4) Thinking on Information Interpretation and Conclusion

The information interpretation and conclusion were the description of the changes that had affected one part of the information to another by predicting and identifying the relationship within the extent of the existing information. This would also relate to the result presentation in forms of graph or table referring to the information obtained through observation. The conclusion of the result of hypothesis testing was the answer to the problems or response to the research objectives and recommendation for the researches to come (Landsberger, 2004).

There are 5 steps to interpret the information and conclude the results as follows:

1. Examining nature of information gained from the hypothesis testing

2. Describing the change that affected one another among parts of the of information and explaining the relationship of information.

3. Answering the problem or research questions referring to the information acquired from the hypothesis testing.

4. Making conclusion if the information obtained from the hypothesis testing accepted or rejected hypothesis and why.

5. identifying obstacles and problems and ways to solve them and additional recommendations for further researches.

The thinking to inteprete3 the information and make conclusion was the thinking occurring at the last step after which the students had identified problems, set up the hypothesis, and tested the hypotheses by acquiring the so clear information that they could find the interrelationship among pieces of information enough to make the conclusion and answer to the main problems along the research objectives.

This research would focus on scientific thinking skills resulted from the the students had engaged in the learning activities along the scientific process through the knowledge enquiring methods along 5 Es which included: 1) **Thinking for Identifying Problem** referring to the thinking to identify the problems. It was the thinking occurred after the students had examined the basic information, investigating the situations, analyzing and selecting the crucial issues to clearly identify the problems, 2) **Thinking for Setting up the hypotheses** referring to the thinking after the students had clearly identified the problem and then collected the facts relating to the problem, analyzing and synthesizing information to be used to anticipate the answer to the problem by selecting the anticipation that was clear on variable identification and g**u**ideline for testing the hypothesis, 3) **Thinking for Hypothesis Testing** referring to the thinking occurred after the students had clear hypothesis along with the design of the method and procedural steps to test the hypothesis and setting up the models for recording results basing on the information acquired to lead to the process of hypothesis

testing, and, **4) Thinking for the Information Interpretation and Conclusion** referring to the thinking occurred after the students had acquired information from the hypothesis testing by analyzing the acquired information to find the meaning and the causal relationship to lead to the conclusion along the set research objectives.

The researcher assessed the scientific thinking skills of the students by observing, noting down the studying behavior, and checking the work done by them while engaging in the learning activities in the classroom and creating the scientific project aiming at observing the learning behavior or the works done reflecting their scientific thinking.

Organizing science learning process through inquiry method

Meaning and Significance of Knowledge Inquiry

Knowledge inquiry was the activity by which the learners studied and developed knowledge concerning scientific knowledge discovery by scientists (NRC, 1996; 200). Similar definition was also proposed in the research conducted by Roehrig (2004) which found that the learners would be able to learn science if they knew how scientific knowledge had been acquired. Likewise, the Institute for the Promotion of Teaching Science and Technology (IPST) had stated that the knowledge inquiry was an instructional model basing on constructivism which contended that the process by which the students enquired and surveyed for knowledge leading to their understanding and meaningful knowledge acquisition to the point they could construct the body of knowledge by and for themselves and kept the knowledge in their brain for the long period and could retrieve it when they required in to deal with the situation confronting them (IPST Biology, 2007).

Lane (2007:7) stated that knowledge inquiry could be done in many ways either alone or in group to enable the students to solve the problems. The activities or works could be carried out both in the classroom or outside. The important point was that the learning model could be adjusted to fit the student's ability to learn and understand the contents in the curriculum. The process opened the opportunity for the students to take part in learning at higher extent. The instructional model at the present has moved toward student-centered instruction than the teacher-centered one. This could open the

opportunity for the students to be able to learn the content, raise the questions and set up hypothesis by themselves. They could learn and analytically think by themselves to higher extent enabling them to acquire the knowledge and understanding on the subject. Similar effect was also observed by Wu and Hsieh(2006) who stated that the knowledge inquiry had involved variety of learning processes including questioning, designing the information survey, analyzing, concluding, inventing, idea sharing, and communicating the explanation. In short, knowledge inquiry was the process used by the scientists to explain the natural phenomena basing on evidences and reasons. Another explanation of the method was the process by which the students used in enquiring for the answer on systematic basis to describe and explain the events needed to be studied.

Banchi, H. & Bell, R. (2008:26-29) had come up with the 4 levels of knowledge inquiry, namely, 1) Confirmation Inquiry carried out by the teachers who could then provide principles, conclusions, and variety of knowledge to the students through questioning, methods, and the conclusion, 2) Structured Inquiry – the knowledge inquiry which the students could check the knowledge provided by the teacher along the steps or process prescribed by the teacher, 3) Guided Inquiry – this was knowledge inquiry which the students could enquire for knowledge via the teacher's guide or using leading question to enable the students to design and choose the method of knowledge construction by themselves, and 4) Open Inquiry – This was the knowledge inquiry which the students created the learning model, designed the method of constructing body of knowledge by themselves. Likewise, Abrams (2008:6) had explained further about the 4 levels of knowledge inquiry that 1) the Confirmation Inquiry could be operated by the teachers who had prepared the knowledge or variety of experiences for the students and setting up the procedural steps or method for the students and expected that all the students could get the answer or learning results all alike, 2) Structure Inquiry was the knowledge inquiry whose model as well as the needed questions were prepared for by the teacher but opened for the students to design the way to discover the answers and check up the knowledge along their own approach, 3) Guided Inquiry was the knowledge inquiry which the teachers had assigned the topic for the students who would identify the main issues and questions and plan to find the answer by themselves, and, 4) Open Inquiry was the knowledge inquiry in which the students

would identify the issues or develop the project on constructing knowledge by themselves on what they were interested to know about.

Process of Knowledge Inquiry in Science

In the instructional provision, the teacher could choose the one that assure the learners learn science the best through variety of processes of knowledge inquiry along the context of the teacher, the learners, and the school and available learning resources in appropriate way. The teachers would support the students to survey variety of phenomena and encourage the students to build up correct understanding in science (Hogan & Berkowitz, 2000). The teacher should transform the instruction that focused on having students explain from the textbook to the one that focused on surveying the questions and issues of their interest centering at the students. She should then get the guideline for implementing the instruction as follows:

- The teacher has process or activities of teaching that stimulate the learner's thinking and analyzing the thing to be learned to the point they could raise the questions for the inquiry by themselves.
- The teacher has the materials or media to facilitate the learners in using to stimulate their thinking, analyzing, or inquiring for knowledge on the topic to learn.
- The learners enquire the knowledge /answers using the feasible process of knowledge inquiry.
- The teacher helps develop the skills required for the learners in studying and analyzing and concluding the information or constructing knowledge that is meaningful to them such as skill on analyzing the things being read, presenting the information, discussing and debating on the academic issues and engaging in the group work, for example.

The Institute for the Promotion of Science Technology Teaching (IPST) has been the agency responsible for curriculum and instruction on teaching science and technology. From the beginning, it had set up the guideline for science instruction using the learning complete process of the inquiry approach that linked between the science content and developing the process of thinking, surveying and examining for the answers, and problem solving. The

process had implanted the characteristics of scientist to assure the student's "ability to think and solve the problems" through scientific process by designing the instruction utilizing the 4 steps of process of knowledge, namely, engagement and exploration, explanation, elaboration, and evaluation. These 5 steps of the learning process were the things the teachers had to encourage the students to learn how to think and be creative. The teacher should give the opportunity for the students to use their own thinking as much as possible. The activities in which the students would inquire had to link to the existing thinking and led to the inquiry of the new knowledge and use the processes and skills in science and knowledge inquiry. IPST (2003) and IPST Biology (2007) had come up with the cycle of the steps mentioned as in Chart 2.4 as follows:

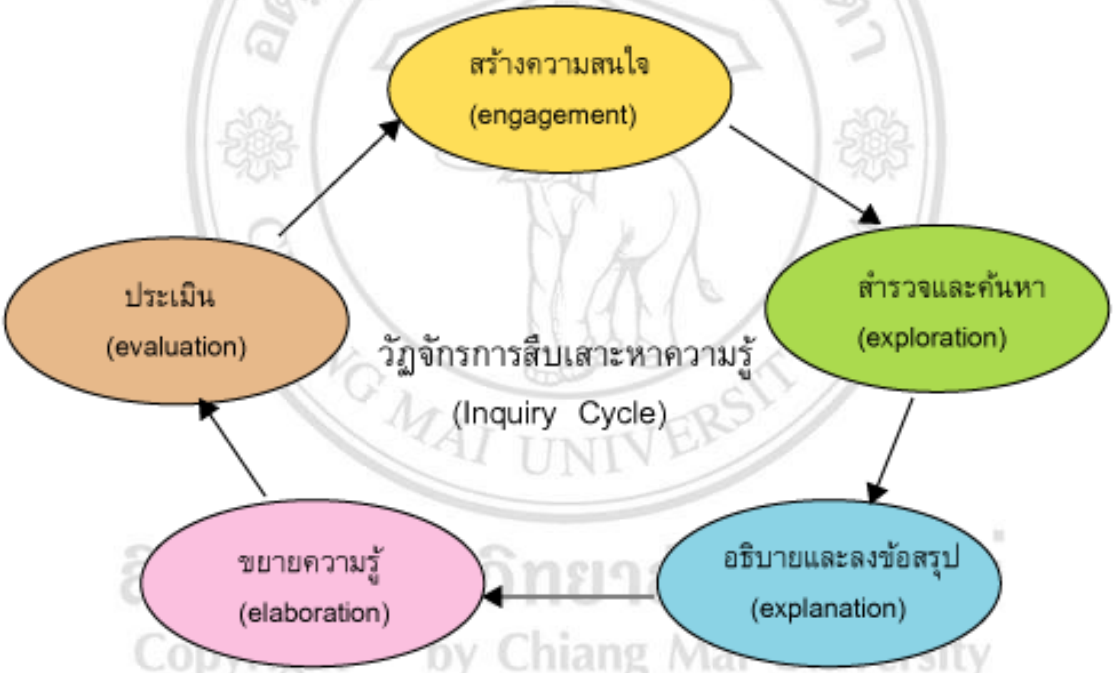

Chart 2.4 Cycle of Knowledge Inquiry

There are some details on each of the steps in the knowledge inquiry cycle as follows:

1. **Engagement**- It the process to lead to the lesson or an interesting issue which could occur from the doubt or interest of the student him/herself or as the result of the group discussion on the interesting issue which could be drawn from the happening event at that particular period or the issue related to the existing knowledge

that had just been acquired stimulating the student to raise the question and determine the issue to study on. In the case when there was no interesting issue coming up yet, the teacher might set up the activity or situation to stimulate or challenge the students to be excited, curious, or conflict leading to the problem solving, searching for knowledge, or experimentation. However, the teacher should not force the students to accept the issue or problem simply interesting the teacher. She should organize many kinds of activities such as demonstration, experimentation, information presentation, telling story or event, having students study or read, discuss, talk, engage in conversation, and use games, media, materials and equipment, creating situation or problems that were interesting and surprising.

2. Exploration – At this step, the students would explore, try, and collect Information, and set up the plan to explore and validate or design the experiment, put into practice, such as observing, measuring, experimenting, collecting information, or introducing variety of phenomena.

3. Explanation – At this step, the students used information acquired through the survey and searching to analyze, interpret and discussed along the presentation of the work done in various forms including the drawing, table, chart, etc. with reference to support the reasoning and conclusion. Such references had to be valid and reliable with clear sources.

4. Elaboration

4.1 The teacher organized the activities or set up the situation for the students to gain deeper knowledge or with wider perspective or link the old knowledge to the new one or led them to study and experiment in higher extent such as raising the issue for the students to explain or discuss with additional idea expression to make it clearer. She should also ask the students for more explanation to make it clearer to them on the knowledge resulting from linking the newly acquired knowledge to the previous one.

4.2 The students took part in the activities such as explaining and expanding old knowledge with more details. They should be able to raise the situation to exemplify the linkage between the knowledge making it more systematic and more in-depth or more complete with details leading to new knowledge or deeper knowledge

assuring better applicability in other issue or situations or raising new questions and designing the form to survey and search information leading to the construction of new knowledge.

5. Evaluation – At this step, the teach had students identify all the things learned both in terms of the process and the products to validate the knowledge just acquired. Through the process, the students would have the opportunity to analyze, criticize, and exchange knowledge among one another. They could acquire comprehensive thinking both in terms of the process and the products and discuss how to evaluate, revise and conclude. If some problems existed, they had to review it again citing the theories, principles, and criteria to compare the results with the hypothesis and compare the new and old knowledge.

In this research, the teachers would develop the instructional plans along the 5 step inquiry cycle, namely, Step1 – Engagement, Step 2 – Exploration, Step 3 – Explanation, Step 4 – Elaboration, and Step5 – Evaluation, which be used to organize the activities on science learning at Mathayom Suksa 3 emphasizing on having the students practice scientific process to develop their scientific thinking skills.

2.5 Related Literature

Research Conducted Related to Teaching Profession Development Through Lesson Study

Lesson Study Group at Mills College (2004) – This was the study on the changes on mathematics teachers who were divided into groups each of which had 3 – 5 members. The lesson study started in 2000 by collecting the information during 2001- 2003 and found that after the teachers had joined in the process of lesson study, there were changes on them including 1) Knowledge understanding on the lesson study process, 2) Ability to work out along the process of lesson study, 3) Understanding and Recognition of learning and development of the students, 4) Ability to observe and compile information, 5) Constructivism and role assignment in the group work, and, 6) Leadership of the teachers. Moreover, it was also found that the lesson study had led the teachers to have deeper knowledge on the contents, theories, and measures resulting from the the student's learning through the process of mutual

learning of competency developing groups in linking the practice to the goals enhancing their motivation in the task development.

Maria (2005) had surveyed the "Lesson study" of those who would become 18 mathematics teachers at secondary education level aiming at studying the development of those who would become the teachers by studying the lesson – Microsoft (MLS) which was a way to obtain experience on the study and quality analysis from various information sources. These materials included video-tape lesson, exercises, review, observation, and survey. It was found that the Project's participants had increasing understanding and could improve the methods of teaching and developing knowledge and competency on teacher in higher extent. It had been a consensus that the experiences and various components the occurred were useful and significant to the process of teacher development.

Podhorsky (2005) studied on Reshaping teacher professional development : Perception of Lesson Study as model for change at University of California at Los Angeles, and found that the instruction had been reshaped to pass the instruction check and effect of the instruction on the student's learning. To assure such impact, the school had to create the process for the teachers to systematically study on the teaching strategy to increase the achievement of the students. This research project had introduced the lesson study used to teach 16 Grade 5 students as a way to enhance the understanding on part of the students in mathematics subject and had the teachers entering to the effective professional development. The teachers taking part in this study had learned through process of lesson study to refine and reflect on the instructional strategy and develop the instructional plans that helped enhance understanding of the students. It was found that the lesson study was a way for the teachers to improve their instruction in a more systematic way and deduct the isolation of the teachers in the process of lesson study. The teachers could work together in setting up the instructional plans and observing the instruction, focusing on the student's learning and professional collaboration that led to the group process.

Susan (2005) had conducted the research on examining the lesson study as an instructional tool in the state school in the US by Ashland University aiming at the need to decide if lesson study could be relevant to the work culture of the teachers or not by compiling information concerning attitude and belief of the teachers toward the process

of lesson study from 9 teachers, 3 administrator, 1 assistant teacher, and 2 focus group discussions, all of whom had taken part in the lesson study at various steps. It was found the model lesson study of Japan had gained interest as the tool for professional development building up instructional skill of the teachers assuring them leading role in improving the classroom instruction. Lesson study was designed particularly for setting up the standard of mathematics and science instructions. Lesson study then had become the tool for the profession development that enhanced knowledge on the contents for the teachers including their skills. In the lesson study carried by this research could be used to predict the future of lesson study which would be sustainable along the instructional culture of the US to implement such instructional strategy in the classroom.

Puchner and Taylor (2006) had come up with an article titling *Lesson study, collaboration, and teacher efficacy : Stories from school-based math lesson study group*. This article explained lesson study and experience of 2 groups of teachers in the US who attributed the change and progress of the teachers to the lesson study. The first case was related with efficacy of the teachers when a group of teachers had found from the lesson study that planning and work in advance had an impact on student engagement in the classroom in a way they had not realized. The second case was about the teacher's struggle with the move from isolation to collaboration that often occurred during such transition.

Triwaranyu, Charinee (2007) had studied the competence development on instructional provision of elementary education teachers along the lesson study framework. It was found the process of education via the lesson developed to become the working process of teaching profession development in the context of authentic working of the individual through collaborative group working on systematic and continuous bases to develop the instruction emphasizing the thinking development and learning of the students. The process through the lesson study was composed of 6 cyclical steps including 1) Setting the study goals through the lesson, 2) Lesson planning, 3) Classroom instruction and observation, 4) Examining the results of the operation, 5) The revision of the lesson, and 6) Learning exchange on the operation through the process of the lesson. The teachers could adjust the operational steps to suite their authentic operation but still maintaining the main components of the process.

Such main components included 1) Collaborative working, 2) Setting the issues for the study through the lesson emerged from the problems on thinking or learning in the real classroom teaching, 3) Observing the behavior that directly reflected learning and thinking of the students in the classroom, 4) Reporting the reflection results and discussing the operational results, 5) Long-term operation and pushing forward the process in relevance to the context of real work by the teachers, and 6) Participation of knowledgeable persons.

Inprasit, Maitree, et al. (2007) had tried the lesson study in the Thai context using an open approach of developing the thinking process of the students to promote the mathematics teaching profession development utilizing lesson study. The research findings reveal that in the first period of using lesson study open approach, the teachers were rather worried and lacked of confidence in their roles in carrying out the new instructional activities and had no confidence on constructing the open-approach instructional plan. The students themselves were not familiar with new approach but were still stuck with the culture of traditional instruction making them dare not talk, express ideas, nor question if doubted. When they had to write, they could not write to explain or describe the methods or reasoning to the peak of their potential. They still stuck on concluding the result. Concerning the class presentation, the students dared not speak up but spoke with soft voice. The teaching schedule has not yet settled down. At elementary school, other teachers were unable to observe the instruction carried out by their colleague during the time they had to engaged in their responsibility on every subject and the teaching schedule was not flexible enough. Later on, it was found that:

1 . The teachers had more understanding and self-confidence on organizing instructional activities in their class and had modified the methods and guideline of the instructional provision along the lesson study and open approach particularly the mathematics teachers at Prathom Suksa 1 and 4 and Mathayom Suksa 1 . In other subjects and levels, there had been the application of the approach in certain periods.

2. Perspective on instructional provision in the classroom and the students had changed. The teachers had come to view that the teacher's instructing or teaching the students to do what or how was easy and had confidence that the students could do it. To teach the students to do and think by themselves or realize the cause and effect of things and reasoning needed to be more emphasized.

3. There was the network and system of internal supervision. At any time of instructional provision, there would be the teacher's colleagues who were available at the period to come to observe and collectively reflect the instruction which was the new phenomenon that hardly occurred in the old schooling system.

4. The teachers had opportunity to work together in constructing the instructional plans, observe the class, and reflect together at the end of every instructional period in every week though in certain week, the participation might be less due to the burdens of the teachers.

5. Results of the instructional provision along the lesson study and open approach reveal that the teachers had increasing consult with one another concerning the learning providing plans, the activities, and roles of the teachers, the teacher's learning behavior. Similar changes were also found among the students. They had become more active in working together and were more expressive with speaking up and could present in front of the class to propose ideas and ways of doing thing of their group. They were more encouraged to think differently and diversely. They could get involved with the problems or activities longer without easily giving up and had better attitude toward group working or working with the others.

Inprasith, Narumol (2009) had studied the use of lesson study innovation to develop the teachers and the students in Thai language and found that the use of lesson study in teaching profession development had made the teacher's change on the belief on his/her learning provision. He or she could change his or her roles and attitude toward the students leading the students of have the learning and thinking process. While studying Thai language, they had better attitude toward Thai studying. The factors determining success in using the lesson study in the teaching profession development were the supports of the agencies under which the school had affiliated. Another factor was the support by the school's administrator, the cooperation with the outside expert. The teachers also gained the confidence that lesson study was an opportunity of acquiring profession development experience in working together along its process and approach of learning provision.

Miniitaraphan, Atthasart (2010) had studied the development of mathematics teachers using the lesson study and development and found that 1) Regarding the acceptance of the lesson study and development, it was found that the participants had

accepted the lesson study and development at high level, 2) Regarding the knowledge change in mathematics content, it was found that, after having participated in the research, the mathematics teachers had higher level of knowledge on the mathematics content after taking part in all of the steps of the research, 3) Regarding the effectiveness of the working together in the lesson study and development of the teachers after taking part in every step of the research, their effectiveness was higher after the participation. It was at very good and good at after and during the participation respectively, 4) Regarding the appropriateness of the mathematics lesson, it was found that the mathematics lesson for instructional provision at the first round and the second round had the appropriateness at better level than the mathematics lesson developed by the mathematics teachers before taking part in the research. They rated the appropriated at very good, very good, and fair levels respectively.

Pattanajak, Aujit, et al. (2011) had studied the mathematical communication of the students in the teaching profession development process utilizing lesson study. It was found that in the classroom where mathematics were taught through the open approach which opened for opportunity for mathematical communication of the students in the aspect of learning. The students had mathematical communication covering 3 aspects - accuracy, worthiness, and freedom of thinking of communicative participants reflecting the enhancement of the student's ability in mathematical communication at higher extent compared with other general classroom. The emotional aspect of the mathematical communication had highly improved compared to the mathematics classes in general. The emotional aspect of mathematical communication could be regarded as an emotional experience. The students had this experience along mathematical communication at every step of instruction. The most found emotional experience was the confidence in one's own answer. Next to that was the emotional experience of excitement and fun, emotional experience of thinking, emotional experience of being interested and concentration, emotional experience of acceptance way of thinking of others, emotional experience of excitement to see if the answer was right, emotional experience of being surprised, etc. Emotional aspects were the crucial part that led to mathematical communication of the students for the clear concept and right answer.

Inprasit, Maitree, et al. (2512) had developed the method to develop the thinking process of the students along the open approach to promote the mathematics teaching profession development using lesson study. The research's findings reveal that 1) The process mathematics teaching profession development using lesson study and open approach had promoted the research on setting up the learning plans utilizing the naturally developed feeling of the students in responding to the order, recommendation and the past experiences of the teachers, observing teachers, researcher, school coordinator, and expert and their reflections on the work done by the students in activities having been carried out. Basing on these, the learning plan suitable to the students was created to assure the student's process of learning by themselves on natural pace and continuous basis; 2) The lesson study process was related to the classroom research along lesson study approach. The teachers could carry out the classroom research process such as the collective effort in setting up the learning plans in relation to the research problems one which was to see if the teachers could set up the research problem using information obtained in the real classroom. At the step of classroom observation, it was related to the information collection. That is the teacher, the observer teachers, the researcher, and the school coordinator and experts could collect information from the real situation occurred in the classroom relevant to the research problem. At the step of collective reflection on the lesson after the teaching, it was related to the analysis of the information. That is the teacher, the observer teacher, the researcher, the school coordinator, and the experts could use the information collected through observation and compiled it to reflect when analyzing the issues related to the problems previously occurring in the classroom. They had collectively discussed which, in a way, could help validate the information acquired using perspective of the classroom observers to help check the validity of the information along the triangulation approach to assure information analysis's reliability and could help solve the classroom problems; 3) The lesson study and open approach innovations used in the school had the steps appropriate to the teaching profession development and process of the student's learning and could lead to the change in the classroom culture as well.

Researches Related to Scientific Thinking

From analyzing the researches related to scientific thinking conducted by many academics , the findings found are as follows:

Dunbar (1997) had studied the thinking and scientific reasoning of 21 scientist on micro-molecule biology by observing their behavior during the consultation meeting among members in the lab and interview on working of 4 scientist on micro-molecule biology who were globally well known at the universities in the US during one year period of study. The findings reveal that the new scientific thinking and concepts occurred through the consultation meetings of the scientists in lab. In each of the meeting, members would present the research findings and the progress of the operation to the senior scientists and other members of the lab. The meeting participants would raise some questions and provide recommendations concerning the experiment and setting up of the new hypothesis as well as the reinterpretation of the information guided by the senior scientists who had crucial role in facilitating the development of new concepts in the meeting. Reasoning made by scientists always came up naturally through the research presentation and interaction among the lab members. The consultation meeting of the lab members was thus significant for creativity and scientific reasoning.

Crowley, et al. (2001) had studied the exchange on scientific thinking between the children and parents during their visiting museum by observing the ability in collecting evidences and using theories to evaluate the evidences. The research findings reveal that the children who were visiting the museum and had exchanged scientific thinking with parents would have higher opportunity to learn than the children who exchanged scientific thinking with friends of the same age or the children who visited the museum alone. The children who visited the museum along their parents had wider survey and spent longer time to do it. The parents used comparison, selected the appropriate evidences, presenting abstract principle or explained the causal relationship linking to the existing knowledge of the child to modify and promote scientific thinking on the child.

Kaewdee, Watcharaporn (2005) had study the development of the instructional process along interactive constructivism to promote scientific thinking and ability of present scientific work of the students at secondary education level and found that the

development of such instructional had 4 main principles, namely, 1) Challenging ideas or creating conceptual conflict, 2) Interaction with the environments and other people, 3) Self-Reflection, and, 4) Work presentation. The instruction could follow the following 5 steps: 1) Examining knowledge and understanding, 2) Challenging idea or creating conceptual conflict, 3) Eternal interaction, 4) Presenting information, and 5) Internal interaction. Results of evaluating the use of the instructional process having been developed reveal that 1) Experimental group had mean score on scientific thinking after the instruction than before at .05 significance level, 2) Experimental group had the mean score on scientific thinking and presenting the scientific work higher than that of the control group at .05 significance level.