CHAPTER 5

Conclusions, Discussions, and Recommendations

This study on development of mathematics curriculum to promote learning and innovation skills of the 21st century through the application of Lesson Study, the purposes were to develop the Mathematics curriculum to promote learning and innovation skills of the 21st century, and to study the results from using this curriculum in Wiengjedee Wittaya School. Collaborative participants in this study consisted of 14 persons. They were 5 school executives including Academic vice Director, Chief of Academics Affairs, Chief of Research and Human Resources Development, Chief of Curriculum and Instruction, Mathematics Department Chair, 8 mathematics teachers and the researcher. The participants who used the curriculum were teachers in mathematics department of Wiengjedee Wittaya School, Lee district, Lamphun Province. In this study, researcher and participants had developed a curriculum according to Taba's model combined with the applying of lesson study approach. Research instruments used to develop the mathematics curriculum were focus group meeting minutes and videotapes. Research instruments used to study the results of using the mathematics curriculum were the 21st century skills performance observation form, videotapes, audiotapes, field notes of the researcher. Qualitative data were analyzed data from observation, field notes, tape scripts, meeting minutes and finally made summarization. Quantitative data were analyzed and presented in form of frequency and percentage. The conclusions, discussion and recommendations were as follows:

5.1 Conclusions

From the research we got mathematics curriculum to promote learning and innovation skills of the 21st century through the application of lesson study and results from using this curriculum were described below.

5.1.1 Mathematics curriculum to promote learning and innovation skills of the 21st century

The mathematics curriculum from the research was subject curriculum that serves the needs of school which policy promotes the international standards and emphasized higher-order thinking skills. The curriculum was implemented for grade 7 students focusing on learning and innovation skills of the 21st century in accordance with the Partnership for 21st Century Skills (2009) which aims at learning skills and innovation i.e. critical thinking and problem solving, creativity and innovation, communication, and collaboration (or 4C's). This curriculum comprised of 4 learning units; unit 1: Integers, unit 2: Powers, unit 3: Basic Geometry and unit 4: Math Project, which were taught by using open approach 32 teaching hours. The researcher employed the idea of Taba's model combined with lesson study approach. Moreover, the researcher used lesson study approach in the stage of development for each lesson plan, as concluded below.

The curriculum resulted from the collaboration in analyzing states of problems of school via several discussions between the researcher and school executives. The school had a policy to promote the international standards school and emphasized on higher-order thinking skills which accorded to learning and innovation skills in the 21st century. In the curriculum development process, a group of teachers in the mathematics department were willing to participate in this process. They thought that the curriculum should be implemented in junior secondary students, and then the researcher presented the feasibility for the curriculum development by apply lesson study. After that, a meeting with teachers was organized in order to plan and set principles and objectives of the curriculum. Summary from the meeting was that the learning management, which aimed for students to have learning and innovation skills in the 21st century, should compose of proper teaching techniques, an open approach was chosen. In the following meeting, the content should be in the basic mathematics course for grade 7 that consisted of Integers, Powers, and Basic Geometry. Additionally, students had to create mathematical games to represent

their creativity. The participants and researcher had formed learning units, contents, and learning hours which eventually comprised 4 learning units for 32 teaching hours. Participants and researcher also decided to have meetings for planning each learning plan in period 9, every Tuesday. Furthermore, we identified the persons who would attend the class to do observation of the learning management as well as to give reflection and suggestions after the class with a teacher in each period.

For developing indicators 21st century skills, the researcher organized a focus group discussion with chief of curriculum and instruction department, and 4 mathematics teachers. In the beginning, the researcher showed video of a lesson taught be means of open approach by a Thai teachers. In the class, observers were present to observe students' behaviors and whether or not. After watching the video, the teachers discussed together and set the indicators for learning and innovation skills of the 21st century which would be used to evaluate students' behaviors. The desired behaviors were 1) critical thinking and problem solving, 2) creativity and innovation, 3) communication, and 4) collaboration. For the stage of planning for each lesson plan, there were mostly 4 persons who joined the meetings; two teachers who taught in grade 7, one teacher who taught in grade 8, and the researcher.

The observation stage was to see how the curriculum when it was implemented in the class. This stage included 17 observation times and there were at least 2 observers were in the class; one from grade 7 and one from grade 8-11, and the researcher as a teacher who run the class. Before the observation, the researcher had a meeting with the observers so as to have mutual understanding on the purpose of each lesson including the objectives of each learning plan, things to observe such as learning management of teacher, appropriation of problems given, and use of learning materials. Furthermore, the observers had to look for students' behaviors which indicated that they had the desired learning and innovation skills (4C's).

During the process, the observers used the observation form as well as the video tape recording. The overall image concluded from the observations in each

lesson plan was used for further revision in learning activities, open ended question, materials, contents, questions, and classroom management. With regard to learning and innovations skills, the study revealed that students had shown all of the 4 desired skills. However, the indicators were not covered in the framework for evaluating each sub-skill. Additionally, in some lesson plans, students displayed behaviors which increased/decreased from the desired ones. Furthermore, suggestions in each period helped to revise tools used for the observation i.e. observation form for learning and innovation skills (4C's) for 2 times. We eventually got the form, which consisted of 4 sequential stages of teaching in open approach, whereby behaviors found in the class observation and behaviors showing the learning and innovation skills were documented.

In the reflection stage, to evaluate the curriculum, the researcher used focus group discussion among the administration team, mathematics teachers, and the researcher. The study revealed that the administration team and mathematics teachers (12 persons) to calculate as 85.71% agreed that the curriculum was suitable and had potential lead students to the development of thinking skills, critical thinking, and ability to solve problems. Students could solve unseen or unfamiliar problems in various ways. They also had creative thinking, communication skills; speaking, listening, writing, and collaboration skills which included teamwork, flexibility and accommodation to achieve the set goal. Nonetheless, the curriculum had some limitations such as high time consumption and it was suggested that we reduce the number of lesson plans by combine the overlapped or related contents into one learning unit.

5.1.2 Results from implementation of the mathematics curriculum to promote the 21st century skills and innovations

From the research we found that students had learning and innovation skills of the 21st century arranged in order from most to least prevalent as follows; collaboration, communication, critical thinking and problem solving, and creativity and innovation. In consideration of development of learning and innovation skills found that during the lesson plans 1-3 students initially developed collaboration skills more than other skills. The skill had developed

through group work, discussing and exchanging ideas between peers and teacher. After that, other skills like critical thinking and problem solving, and creativity and innovation, which needed time to practice and develop were getting better in time.

Having considered by the indicators of each skill it was found that the behaviors of 4 skills that most of students had were collaboration, communication, critical thinking and problem solving, creativity and innovation. First, collaboration, students had to work in a group, so they had to be responsible for the outcomes and recognized others' roles in the group. Second, communication, students could communicate with others in various ways; speaking, writing, and had effective listening ability. They had joined in discussion among peers in groups and in class. Third, critical thinking and problem solving, students could think rationally by using reasons, discretion, analyzing, comparison, synthesizing and linkage. They showed their curiosity in the state of the problems, decision making, and attempted to find out supporting ideas. Finally, creativity and innovation, students had various perspectives. They could create alternative points of view and represent their ideas that were different from what they had before or were different from others. They joined the process of making understanding, revising, analyzing, and evaluating their own perspectives. They also could create innovation by taking action based on their creativity, including the ability to create learning styles/tools for self-learning.

5.2 Discussions

In the study of the mathematics curriculum to promote learning and innovation skills of the 21st century through the application of lesson study, discussion on the study's results is presented below.

5.2.1 The development of the mathematic curriculum to promote learning and innovation skills of the 21st century by using Lesson Study Approach.

The study developed a curriculum according to Taba's combined with the applying of lesson study. As a result, the curriculum which conformed to the school policy and developed collaboratively by teachers and staffs in the school.

The development of curriculum was carried out by users who worked corroboratively from the very first stage to set objectives establishment, creating learning management guideline, learning activity for each lesson plan, and evaluation tool. Additionally, they joined the observation and reflection and group discussion. They collaboratively evaluated both during the class and for the overall image of the curriculum. These processes accorded to Taba's model for curriculum development which states that a curriculum should be developed from users and teachers, who should participate in the developing process (Taba, 1962 cited in Ornstein, C. A. & Hunkins, P. F., 2009). Moreover, the applying of lesson study approach could promote teachers to have collaborative skills. They had to work with others in school via forums for discussion and reflection.

The developing process using Taba's concept and Lesson Study Approach consists of 3 stages; 1) collaboration in curriculum design, 2) collaboration in the curriculum observation and 3) collaboration in reflection or post-discussion. This study used Lesson Study Approach in the developing process for each lesson plan as introduced in Inprasitha (2010) in order to provide clearer picture of the developing process and could directly serve the users' need. By Lesson Study Approach, teachers came to meet and discuss from time to time to develop lesson plans (Inprasitha, 2004) analyze the state of problem, need, figure out how to make students understand and develop their learning process (Perry and Lewis ,2008). The curriculum's objectives were then set out and teachers planned for the next meetings for lesson plan design, generally on Tuesdays in the 9th period. In the meetings, classroom observer was designated for each lesson plan as well as a requirement for the collaboration of reflection right away after finishes the class. Additionally, the well planned schedule did really help for systematic working and continuation of the collaboration.

In the beginning of planning stage, a concretized example was given as a guideline for teachers to build on for lesson plan design and group discussion on related topics. For instance, after the principles and objectives of the curriculum including learning management, units of learning, content, and teaching hours were set, teachers were discussing further on indicators for the evaluation of 4C's

skills. In the meeting, a VDO example of using Open Approach was presented in order to better their understanding about learning management. The VDO helped them out in the discussion to determine indicators for the evaluation of learning and innovation skills in the 21st century. Moreover, examples of documents describing the behaviors of learning and innovation skills of the 21st century were also provided. Regarding a process of the collaboration in lesson plan design, if teachers were from different levels, such as from junior high to senior high, each lesson plan would be encouraging especially in a process to create the state of problem due to their different points of view. By doing this, teachers were truly engaged in the discussion for lesson plan design in lesson plan 1-3. There were mostly 4 participants in this process; 2 teachers from grade7, 1 teacher from grade8, and the researcher. According to the important tasks caused the absence of other teachers. As a result, in some lesson plans the questions were not designed successfully to encourage students to think and work together.

Within the collaboration of classroom observation, aimed to figure out whether the lesson could be well implemented as planned or not. A meeting between teachers and the researcher was organized every time before starting the observation and with every lesson plan in order to make sure that everyone were on the same page. Objectives of each lesson plan, things to observe were restated in order to make more understanding. During the observation, an observation form regarding the behaviors/features of the learning and innovation skills (4C's) was provided. After finished with the observations researcher found that the observation form had some limitations in term of record data. Teachers and researcher discussed on this problem and improve the form for 2 times.

Within the collaboration of reflection to evaluate the curriculum, researcher relied on group discussion with school's executives and teachers and found that the executives and mathematic teachers 12 out of 14 persons or 85.71% agreed that the curriculum was suitable and could promote critical thinking and problem solving skills. Additionally, aside from having the curriculum, as a result from the collaboration, the study also reveals that Lesson Study Approach was innovative for teacher professional development which promoted teaming skills encouraging

then to work together in every stage of the development. This also promoted a culture of ideas exchange among teachers in school (Marsigit, 2007) and made teachers felt more self-confident and greater support from their colleagues (Chap Sam, 2006). From this process researcher found that Lesson Study Approach was well implemented with teachers in this school. This was because of school's context and its culture of sisters and brothers, interdependency which limited the competitive atmosphere in school. Teachers in this school were willing to help each other and care of every one at all times. When they were asked for co-operation in the curriculum development project, they were willing to participate. This was a crucial factor for the success of Lesson Study Approach (Lim and Kor, 2013).

Moreover, Lesson Study provides teachers the opportunity to see teaching and learning in the classroom in a concrete form. This is due to the fact that lesson study guides teachers to focus their discussions on planning, implementation, observation, and reflections of classroom practices (Takahashi and Watanabe, 2006).They had a positive attitude towards the betterment and were ready for change. Additionally, in Lesson Study Approach teachers had to meet up from time to time so as to create lesson plans including to discuss, observe the classroom. Their comments and suggestions based on findings collected during the classroom observation led to the improvement of lesson plans (Loifah and Inprasitha, 2004). Nonetheless, in the reality, every teacher could not attend in all meetings organized for lesson plans design and classroom observations and reflections because their teaching schedules did not match, or having other tasks beyond. From many hindrances resulted in the inconsistence of the number of teachers participated in the process of lesson plans design, classroom observations, and reflections. Importantly, if someone participated in some part, they could not make sense of a whole developing process when they were asked to give comments and suggestions.

Moreover, Lesson study was built both collaboration and content knowledge (Lewis and Perry, 2006). Lesson Study Approach promoted collaborative skills among participants through the meetings for discussions and reflections and

lesson study is a form of teacher-led professional development, any teacher can begin lesson study by starting to collaborate with other teachers (Takahashi and Yoshida, 2004). By this means, Professional Learning Community (PLC) had come into being. PLC aims to develop and solve the problems of an organization which focuses on the collaboration in learning for all, learning by doing, and learning process of individuals (DuFour & Eaker, 1998). Wichan Panich (2012) states that PLC is a crucial tool for teacher professional development and helps to promote learning process of teachers and teachers' engagement in working project systematically, continuously. It is teacher-led professional development through lesson study. Teachers are actively involved in the process of instructional change and curriculum development (Takahashi and Yoshida, 2004)

5.2.2 The implementation of the mathematic curriculum to promote learning and innovation skills of the 21st century:

The study revealed that students had developed learning and innovation skills (4C's) through learning management followed Open Approach. By using 4 stages of Open Approach in learning management, students were challenged to think and prove their hypotheses. Through practices, they subsequently acquired the learning skills by themselves (Isoda, 2012). The 4 stages of Open Approach were firstly, posing open-ended problem. In principle, this stage aimed at giving question and let them grasp the meaning of that question. This process encouraged students to think in comparative way between the given question and their prior knowledge and experiences. This made students curious about the question and felt excited, enthusiastic and concentrated on this learning activity. They quickly grasped learning materials and started discussing with peers. This behavior implies the possession of critical thinking and problem solving skills. Furthermore, this also implies that students had initially developed teaming and communication skills.

The second stage was students' self-learning. Basically, this stage was focused on the ability to analyze and find out the answer by them. The study reveals that this stage could promote all 4 skills. In critical thinking and problem solving skills,

students had attempted to find out sensible reason, tried to engage in making decisions process with peers. In the beginning of the semester, students lacked of confidence to take role in the problem solving process and were focused only on how to find out the exact answer. This behavior discouraged them to think about other possibilities. Yet, in the mid of the semester, students became familiar with Open Approach style and could perform in problem solving activities by themselves. They were not focused anymore on the exact answer but more felt comfortable, relaxed, eager, and fun in the problem solving activities. Regarding collaborative skills, students had shared ideas among peers and accepted the different opinions. They could work both in couple and in group of 3-5. Within group activities, students had developed communication skills through talking, discussing, exchanging with peers. This included the ability to express their ideas in written form. Considering creativity and innovation skills, students showed the ability to create learning method/tool by themselves in problem solving activities.

The third stage was whole class discussion and comparison. In principle, this stage was to encourage students to present their ideas summarized from problem solving activities as well as to discuss on the important issues in a whole class. This stage aimed to promote communication skills through discussion with peers in a whole class based on the answers of peers on the whiteboard. Teacher asked questions to find out whether they agreed or not agreed and then asked them to give reasons which helped to promote critical thinking and problem solving skills. By this process, students had attempted to think about sensible reasons in order to make their peers agreed with. Students were engaged in discussion and analysis on answer of each group. This was the co-operation between teacher and students.

The fourth stage was summarization through connecting of the students' mathematical ideals emerged in the classroom. This stage aimed mainly to promote critical thinking and problem solving skills because it was the conceptualization in a whole classroom. Students were encouraged to interpret, explain, and analyze the answer of each student in order to make a common conclusion. Additionally, considering in each skill of learning and innovation skills (4C's), the study reveals that a skill appeared in every lesson plan was

teaming because learning management by using Open Approach was focused on co-working both in couple and in group of 3-5. Therefore, students had a chance to help each other as well as to exchange ideas with peers in group and in a whole classroom. This skill is very crucial for living in the 21st century. Students have to learn how to work with others efficiently and have a creative manner to solve conflicts. Promotion and teaching on collaborative skills and the ability to solve conflicts in creative manner will increase quality of the collaboration and students have to learn more thoroughly (Johnson, 2011). The collaborative skills could be grown well by doing activity both in couple and in group of 3 because it ensures that every member will be engaged in problem solving process. Nonetheless, creativity and innovation skills appeared least because content of each lesson was relatively abstract. This limited the possibility to create a variety of questions accordingly.

5.2.3 Initiating new things in school, if process of the collaboration is informed clearly, it will assist to better learning and understanding of teachers and staff. The crucial mechanism for co-working sphere is the constant support on policy from school's executive board. This will make possible a "good friends atmosphere". The school's executive board is very important in promotion of academic exchange culture among teachers working in school. By doing so, teachers and staff are able to create learning issues for further discussion and then comments and reflections will be fruitful for the improvement and effective learning/teaching process. The study of using Lesson Study Approach with teachers in this school was accomplished successfully because the school's executive board realized the importance of the collaboration within school. Then they supported, promoted the collaborative development of the curriculum to take place in school. This was accordant to Inprasitha (2009) who states that the critical success factor in using of Lesson Study Approach for the development of teacher professional is the great support from school's command unit, executive board, collaboration from external specialists, realization of changes within students and teachers themselves. They also have to trust on Lesson Study Approach as a means for teacher professional development, increasing of experiences in Lesson Study process and learning management.

Furthermore, this was the first time that teachers had an opportunity to exchange their experiences in teaching management as well as the collaboration in lesson design, classroom observation, reflection and discussion on learning activities done in classroom. The school's executive board also supported for learning management by using Lesson Study Approach e.g. scheduling for the collaboration of reflection and discussion and supplying for learning materials. Moreover, teachers themselves were eager to learn new things in order to improve thinking skills of students. One of the most important factors was school's context in which valued the organizational culture of "good friends, interdependency, open-minded for the collaboration of learning and innovation". This context was accordant to Woraluk Chukamnerd et al. (2014) who states that a community of good friends in Thai's way where carefulness, willingness to listen, co-operation within friendly atmosphere linked by the feeling of helpfulness and the emphasis on horizontal relationship like members in a family rather than a vertical form in a chain of command. According to this, teachers feel trusted and comfortable that enhances learning capacity and teacher professional development for the 21st century.

5.3 Recommendations

5.3.1 Recommendations from this study

For those who intended in using or applying the research findings, there are some recommendations as follows:

1. The applying of Lesson Study Approach in the collaborative development of a curriculum, the crucial points to be considered is the willingness of participants. Participants are supposed to take part voluntarily and realize the importance of what they are going to do together not only do their own part of the project. The coordinator should be the leader in organizing the meeting, preparing the documents, coordinating with teachers, and bringing Lesson Study Approach into practice. The project should be included in school's policy so as to gain support from school's executive board such as the support for free periods for conducting classroom observation together as well as the collaborative reflection. This includes the support for organizing learning

exchange forum which helps very much for enthusiasm and continuation of the collaborative working.

2. The development of 4C's skills is a time consuming process to develop the skills, the students needs time and guidelinds from a teacher. From the beginning, teacher should start with practising in communication and co-working skills. In this stage, students will practise in discussion and exchange of ideas between peers and the teacher. Within the co-working atmosphere, they will learn to listen to each other. This stage leads to critical thinking skills, problem solving skills, and creativity and innovation skills subsequently. For applying of the findings from indicators to evaluate the 4C's skills of students, teacher should design learning activities that encourage students to represent these skills in classroom such as an activity that encourages students to talk, discuss, and write or a problem-based activity that encourages students to work together.

3. The schools which have the policy in developing higher-order thinking skills should try open approach process to improve the students' learning skills. For the open approach process had consisted completely procedure provide more opportunities in students' self-learning thinking.

4. For implementing Open Approach, designing of questions should be concerned about the consistence of students' context. Problems should not be too complicated and encourage students think by themselves. Students will have more interest and want to solve the problem. Learning materials should be provided which the students can use by themselves in the problem solving activities. Regarding group activities, a group should be small with 2-3 members so that all members could join in decision making process in order to solve the problem. They can also help each other as well as to share and exchange of ideas and opinions within a group thoroughly. Additionally, teacher should inform the instruction and question clearly before giving them learning materials and let them work by themselves. The questions provided should be open-ended encouraging them to discuss but not true or false. Reinforcement is also important including a process to promote open-minded attitude, listening

skills, and the ability to give reasonable opinions when their classmates are presenting in front of the class.

5.3.2 Recommendations for further studies

1. From lesson study approach in this study, participants were mathematic teachers from various levels which let us realized the differences on ideas and perspectives from experience of each teacher. For further studies, I would like to suggest that Lesson Study Approach should be employed in the curriculum development of other subjects. From this point, teachers will engage in professional activities that enhanced their teaching and enrich students' learning experiences.

2. For further studies, I would like to suggest to study in time management of lesson study approach. In order to improve the efficiency in this process.

3. For researcher who would like to start lesson study approach, should be start with the small scale such as in the school. Because it need strong cooperate co-working to planing, observing, reflecting on the work. Small group makes every co-workers feel that they play an important role in the project.

4. In further studies, an appropriate time management should be taken into consideration especially for Open Approach in all four stages, because inadequate time could affect the incompletion of a lesson for problem solving process. In this study, some periods had a time limit due to many reasons, .For example, in the fourth stage; lesson summary from the linkage of knowledge gained in classroom had to be done sometimes in the following periods. This step, as a matter of fact, is very important because students would do it within the same period in order to link the newly gained knowledge with the prior knowledge and use it as a basement for the next lesson.

5. In further studies, a curriculum aims to promote other 21st century skills should be developed. For example, life and working skills, information, media and technology skills which less concerns about content but more focus on project-based approach in order to promote the problem solving ability in everyday life via practices.