



Using Project-based Teaching for Developing Thai Pre-Service Science Teachers' Attitude towards Science

Sasitthep Pitipornatapin* and Orawan Kuhapensang

Kasetsart University, Bangkok, Thailand

**E-mail: fedustp@ku.ac.th*

Abstract

This research aimed to develop the teaching practices of the researchers as the lecturers about using project-based teaching for increasing pre-service science teachers' positive attitude towards science. We developed and implemented 9 lesson plans focusing on project-based learning in a 15-week Science Project course for 17 pre-service science teachers in the first semester of academic year 2013. Multiple data gathering techniques were used: informal interviews, document analysis such as journal entries and teacher logs. The researchers analyzed qualitative analyzing data with content analysis. The findings showed that best practices of using project-based teaching for developing their attitude towards science are 1) Providing example of science project linked to many disciplines; 2) role playing to be scientist to solve the community problems; 3) connecting their learning experience about science project to the real world; and 4) providing friendly and safely discussion about science project. These findings were considered in terms of further designing course activities.

Keywords: pre-service science teachers, attitude towards science, project-based teaching

1. Introduction

Under Thai educational reform, all learners are regarded as being the most important stakeholders. The ultimate goals are to foster virtue, capability, and happiness in order to educate learners to be of the highest quality (Office of the Education Council (OEC), 2000). To support this idea, chapter 4 of the National Education Act B.E. 2542 (A.D. 1999) and Amendments (Second National Education Act B.E. 2545 (A.D. 2002) provides the guidelines of learning process focuses on a student-centered approach, in which students engage in activities based upon their interests and their individual differences (Office of the National Education Commission (ONEC), 2003). Therefore, the aims of science teaching and learning emphasize on linking knowledge with processes, acquiring essential skills for investigation, building knowledge through investigative processes, seeking knowledge and solving various problems. Learners are allowed to participate in all stages of learning, with activities organized through diverse practical work suitable to their levels (The Institute for the Promotion of Teaching Science and Technology (IPST), 2008).

According to this guideline, Project-based teaching is the teaching approach in the 21st century which focuses on the students' meaningful learning and self-solving (Partnership for 21st Century Skills, 2009). It provides learning activity engaging learners using scientific method to acquire new knowledge. Students will be facilitated and guided by the teacher and will construct their own knowledge which is the ultimate goal of inquiry-based learning process (Buck Institute for Education, 1999). Creating the end-product of project provides students' opportunities to develop their confidence and independence and to work together in a real- world environment (Blumenfeld et al., 1991). For effective project-based learning, the teacher has to design learning activities that leads students to investigate important ideas and questions; is framed around an inquiry process; is differentiated according to student needs and interests; is driven by student independent production and presentation rather than

teacher delivery of information requires the use of creative thinking, critical thinking, and information skills to investigate, draw conclusions about, and create content; connects to real world and authentic problems and issues. Teaching can start with introduce and explain the purpose of the strategy demonstrate and model its use through a mini-lesson, provide guided practice for students to apply the strategy with feedback, allow students to apply the strategy independently, and ask students to reflect and share about the appropriate use of the strategy and its effectiveness (NYC Department of Education, 2009). Many researchers in found that project-based teaching benefits the learner in learning achievement (Boonsit, 2004) science process skill (Faknuam, 1997), scientific solving problem skill (Tagoolrad, 2004) and creativity thinking skill (Samran, 1999). Moreover, teachers often note that it increases the motivation of students, improvement in attendance, and higher class participation (Bottoms & Webb, 1998). Although, project-based learning has many advantages for learner, it also has several limitations in time consuming and recourses consumption. It also requires professional teachers who can set up the proper learning environment (Dosch, 1998).

As a result of the advantages and the limitations of project-based teaching approach, learners' attitudes are different. Attitude is a way of looking at things. It can indicates an individual like and dislike towards an item. It also may be positive, negative or neutral (Muellerleile, 2005). Understanding of students' attitude is important in supporting their achievement and interest towards a particular discipline. In field of Science education, Gardner (1975) proposed a distinction between two different attitudes by apparently term "*attitudes toward science*" and "*scientific attitudes*" which develop simultaneously in a person while learning science. Scientific attitudes possess attributes thought in knowledge and justified belief. On the other hand, the attitudes toward science is related to affective domain presented as feelings or emotion in the expression of favor, disfavor, satisfy, love, hate to the science subject. In this research, researcher conducted a study on attitudes towards Science Projects and will discuss the only the attitudes towards science. If students have the positive attitudes toward the subjects, they will be attentive in class and will participate in teaching and learning activities which its effect on students' achievement.

Thus attitude towards science is very important in teaching science and teacher should strive to develop positive attitude towards science in their students. As attitude toward science relates to many aspects or variables and influences on achievement in science, many researchers are interested in studying. For example, Haladyna et al. (1983) has summarized the factors that influence attitudes toward science are inside school variables (e.g., self-consciousness, teaching quality, classroom atmosphere) and outside school variables (e.g., parents valuing education, social status of teacher, teaching experiences, home environment). This is consistent with the studies of Nuansang (1991) stated that gender, age, levels of achievement, parents' highest level of education, educational background, teaching experience, teaching behavior and strategies, school size, school location and school science facilities are the factors that influence attitude toward science. Moreover, Onocha (1985) reported that teacher's attitude towards science is a significant predictor of learner's achievement as well as their attitude. Osborne, Simon, and Collins (2003) also reported that the quality of science teaching is an important factor affecting students' attitudes toward school science.

Therefore, teacher training course is one of professional development considered important and current worldwide and various countries perform effective reforms. Teaching and learning could be successful depends on the knowledge and experience of the teachers. As lecturers in a teacher-education institution, the researchers took a responsibility for teaching Science Project course. The researchers found that pre-service science teachers' attitude towards science are negative at the beginning of teaching. Their answers in questionnaire showed that they did not like to do science project because it had a complex method and took up their time. Also, students did not have any ideas for doing the project and it was failed. Therefore, the researchers would like develop their positive attitude toward science project in order for them to have a successful learning. It will be beneficial to the pre-service science teachers who are going to be teachers in the future because they could use the science project knowledge to help their students achieve in doing science projects. Also, it has a positive impact on teaching and learning process consistent with the future perspective of national education. For All those reasons, the researchers were interested in developing their attitudes towards science project by using Nature of Science Approach. The results of this research

will guide the institutions and universities to develop appropriately attitudes towards science of undergraduate science teachers. Also, it will guide to develop science project's teaching and learning activities.

2. Research Objectives

The researchers aimed to develop our teaching practice about project attitude toward science projects of undergraduate students in Department of Science Education, Faculty of Education, at the University in Bangkok. To achieve the purpose of the study, the following research question was posed: "*What are best practices of using project-based teaching approach to develop pre-service science teachers' attitude towards science project?*"

3. Operational Definitions

The researcher defined pre-service science teachers' attitude toward science as their feelings or opinions on doing science activities, an awareness of the importance of science, expression of enthusiasm and engagement in science activities which could measure from journal entries, informal interview, and observation. Moreover, project-based teaching in this study means teaching approach that focuses on student's center learning activities that related to inquiry base learning or students used scientific method to answer curious or wonder questions independently under the guidance of teachers or experts until they constructed the new useful knowledge or products.

4. Research Methodology

4.1. Research Design

With the lens of an interpretive perspective, the research design of this study focuses on qualitative study to find the best practices to develop pre-service science teachers' attitude towards science. It involves rich description and evidence from the investigated phenomenon which the researcher has collected and interpreted from research participants and settings (Crotty, 1998: 67). In science education, interpretive methodology is often used to understand the ways that teachers or students make sense of the social interactions both in and around schooling. It also helps teachers better understand what they do in order to improve their teaching (Gallagher, 1991). In other words, it helps researchers to understand teachers' actions and the beliefs that lie behind their actions. As a result of using this methodology, the teachers also get the benefit of being more reflective of their own teaching and learning.

4.2. Research Participants

The participants in this research were the fourth year pre-service science teachers in Bachelor of Education, Department of Science Education, Faculty of Education at the university in Bangkok. They enrolled in Science Project course in the first semester 2013. There were seventeen participants; two males and fifteen females.

4.3. Context of the Study

These participants were studying at a teacher education institution, which has a commitment of generating and developing pre-service science teachers of high quality and standards sufficient for high vocations. The five-year program graduates teachers with the basic qualification of a bachelor's degree. In order to complete the requirements of the program, pre-service teachers must take the following courses: 1) a compulsory general course that includes a compulsory teaching course and a compulsory specialized disciplinary course; 2) elective specialized courses, which include a selective teaching course and an elective specialized disciplinary course; and 3) an elective course. In addition, students must participate in extra activities (e.g., the Science Education into Communities Project). The Science Project course is one of the compulsory specialized disciplinary course in science teaching. The course has the value of 2 units. Researchers started teaching Science Project course from June to September

2013. There was thirty hours in the first semester 2013 divided into fifteen weeks, with two hours per week. (From June to September 2013)

4.4. Research Methods and Collections

To describe teaching practices in Science Project course, the researcher can use various methods for collecting data. Researchers are an important instrument for data-gathering (Jackson, 1995: 9-10). A strong relationship between the teachers and researcher is needed in order to make for a better understanding of what is happening in the classroom (Borko et al., 2008). The researcher also designed nine lesson plans according to project-based teaching approach. The content of Science Project course was composed of 1) Principle and rationale for doing science and technology project in school. 2) Types of project. 3) Components of Project 4) Fundamental principle for project design. 5) Project procedures 6) Roles of project advisers and students. 7) Project evaluation 8) Project presentation 9) Implications for Science and technology project in school. The total was fifteen weeks with two hours per week. Also, researcher has asked the experts to check the content validity of the lesson plans and improve them before using in the classroom. After finish teaching in each period, researcher jot down what researcher had learned in each period in teacher's logbook and assigned pre-service science teachers writing journal to reflect their feeling or opinions about doing science projects and activities. Also, students can post their concerns about the course and their suggestions in the notes which had fifteen journals in total. Moreover, researcher examined the pre-service science teachers' worksheets and products.

For getting the depth details, researcher used the informal interview protocol for gathering the data from student teachers with the aim of eliciting answers in the topics that were not clear or researcher wanted more detail about doing science project. Informal interview was flexible. In order to obtain the desired information, research could modify or restate the questions until students understood the questions. If there was a misunderstanding, research could resolve immediately. After the course had been completed by using the lesson plan that researcher developed, researcher assigned each student to reflect their feeling about doing science project by writing on the paper that researcher distributed. When students had finished their writing, researcher gave students an opportunity to exchange their idea about doing science project compared to their prior idea.

4.5. Data Analysis

Researcher established credibility of the information with a triangulation. Data analysis involved organizing, reducing, and interpreting the data collected from the informal interviews, teacher logbook, worksheets and products and the journal entries. Data were classified as a group. The answers in each group were compared in how consistent or different between them. In the last step, categories and their properties were reduced, refined, and finally linked together to formulate themes to explain the meaning of the data. Then, the conclusion about the attitudes towards doing science projects was generated. After that, researcher would share all of the findings with the participants for affirming the accuracy of data interpretation.

5. Research Findings

The data were grouped based on the themes and patterns that emerged through the analysis processes. A total of four themes of best practices for using project-based teaching to promote pre-service science teachers' attitude towards science were identified with supporting data as follows:

5.1 Providing examples of science project that link to many disciplines

At the beginning of lesson, pre-service teachers were not brave to answer the teacher' questions about science project because they thought that some of science subject are very difficult for them. They did not have enough prior knowledge of doing science project. They reflected that *"It is too difficult to do science project*

because my major is Physics and I don't have much knowledge in Biology and Chemistry. Moreover, I have never done science project"

For this reason, researchers assigned pre-service teachers worked in small group to brainstorming for posting the questions that they would like to know about doing science project. After that the researchers provided them special guest speakers who was the pre-service science teachers who enrolled this course last year and did the science project related to many disciplines and link to daily life. During guest speakers present their science projects, they have to analyze the types of science project, the name of the project, and the components of project. Then, they discussed together for getting the science project guidelines.

According to their discussion, most pre-service teachers (15 people) seemed to change their attitude towards science in the better way. They knew their projects must relate to many science subjects, used scientific process with the guidance of teacher, and must obtain new knowledge. They revealed as *"For doing science project, many subjects can be linked. I have to study more in some part that I have never known before."* In addition, they showed their enthusiasm to discuss more about science project. They identified advantages and disadvantages components appeared in the examples of science projects. They could state what projects' weakness that should be improved. Pre-service teachers also showed their suspicion arising from doing research review and analyzing projects' reports which led to the problems for their studies. Then, they engaged in discussion in order to get the conclusion of sound knowledge. This affected to positive attitude towards science project as an example of the quote in a pre-service's journal which stated that *"I felt impress with the lesson today. Activities made me change my feeling about doing science project. I understand what teacher had taught. I like this learning environment which was thinking by myself first and then having a group discussion. Now I think that science project is not too difficult as I have thought."* Also, another quote in a pre-service's journal stated that *"Today I had learnt a lot more knowledge. I understood the components of a science project and learning by discussing. Sharing attitude made me get more new things. Also, I had learnt that learning was not only listening, but learners also need to question what they wondered or wanted to know in order to create new knowledge."*

5.2 Role playing to be scientist to solve the community problems

One of the factors that affected the pre-service science teachers' attitude towards science was their bad direct experience. Researcher found that most pre-service teachers (11 people) had negative attitude towards science. They claimed that they had less experience in doing science project and the projects were not succeeded. Pre-service teachers did not like to do science project because they feel like they were forced to do it. The project did not occur from their interest. It had a complex method and took up their time, patience and responsibility. Furthermore, some pre-service teachers (6 people) who never do science project had negative attitude toward science project. They claimed that it was difficult to succeed in science project as an example of one pre-service teacher who stated that *"I personally do not like science project very much because it consumed time to get data. If you did it wrong, you need to start doing it from the beginning. I felt frustrate and had a headache when I tried to figure it out what was the issue that we should study."*

For this reason, the researchers had taught science project encouraged pre-service teachers had a role play to act like scientist when they worked on their project by themselves. From classroom observation and notified pre-service teachers about issues related to the nature of science, researcher found that most pre-service teachers (14 people) had positive attitude towards doing a science project. They learned and transferred science process procedure into practice. Pre-service teacher could solve problems occurred during the project. As well as they learned to work like scientists who attempted and untiring patience until success. Pre-service teacher commented that *"Learning by doing helped us to understand how to do science project. In the past, teachers did the project for us. We only did the experiment and decorated the project's presentation. I thought I got nothing from doing the project. However, after I learned this course, I did know more. I knew how to start to do a project. It turned me to be an observer and paid more attention to my surrounding. I used to overlook things and saw a problem from a distance, but now I could see the problem around me. I could study and find a solution for that problem by planning,*

searching data, and doing hand on activity” or could said “Doing science project could link classroom knowledge and daily life experience by searching data, solving problem, doing hand on activity and I could apply that knowledge” or another quote in a pre-service’s journal stated that “It made me responsible for my assignments. It created a unity in working environment and helped me to accept my friends’ idea. Also, it helped to practice my solving problem.”

5.3 Connecting their learning experience about science project to the real world

In order to graduate and being a capable science teacher who taught science project in the future, pre-service teacher needed to receive the direct experience from the teacher who teach science project in school. Research found that most pre-service students did not have experience nor had less experience of doing science project. They did not truly know how to do a project which was a problem to succeed in science project and being proud to work on their own project. All these problems made pre-service teachers lacked of inspiration to convey their knowledge to future students. They revealed as “When I studied in high school, teachers did not teach me how to do science project. I know that it take too much time to do that. Honestly, I am not confident to teach others science project.”

To deal with this problem, researchers assigned pre-service teachers to attend science project contest during national science week. Pre-service teachers videotaped the interviews of teachers who were project's advisor and students who did projects. They also studied how to organize science project boards in the contest. Pre-service teachers would study all steps of doing science project. Next, pre-service teachers were assigned to present in front of the class and discussed together. It found that some of pre-service teachers (10 people) could construct knowledge from their real experience. They learned how project's advisor truly worked and how students did projects. Students gained a variety of knowledge, creative ideas, and certain experiences of doing science project because each school had different issues and used different solution. As an example of a quote of pre-service teacher’ journal stated that “When the judges asked some kids, they could not answer because they remember their presentations. Some kids might not think by themselves. The teacher thought for them. I listened to many projects. There are many projects that teachers help students thought. Also, this is the first time I was at a project contest which made we knew how to display or present our works. It needed to have a brochure, must have a real product and the kinds of questions that the judges would ask. It made me knew everything about the presentation. There was one judge who asked a question in order to prove whether the kids thought and did a project by themselves.” Or a quote in the informal interview showed that “To see the project contest was very helpful. I used the error happened to the children to apply to my project. I thought if I were a teacher who sent a science project to the contest, I would make students themselves thought and did it, so students could really learn.”

Moreover, almost half of the pre-service teachers (7 people) seemed to change their attitude in to the better way from interviewing the science project’s advisors as a quote in a journal said “Teacher helped and gave us some advices and solutions to solve problems that happened during doing a project which helped our projects succeeded. The teachers encourage us to think for ourselves. We felt comfortable to think and express our ideas.” Also, pre-service teachers learned the role of students from doing science projects as a quote from informal interview that “I impressed people in my group. When we had problems, we helped each other to solve them. I could see how kind they were. Although we worked hard with the subject matter, our friends spent their time to do the project. We helped each other very well.”

4. Providing friendly and safely discussion about their projects

In order to change pre-service teachers’ attitude towards science to be more positive, pre-service teachers themselves needed to change their attitude by frequently practicing their skills of doing, presenting, and discussing science project. Researcher found that all pre-service teachers (17 people) were did not feel comfortable to express their ideas. The learning did not occur between their discussions as it should have in the classroom. They did not want to be funny in the classroom if they asked some questions that they have not known before. Therefore, pre-

service teachers always kept quiet. They reflected from informal interview that, *"I don't want to lose my face when I present not so good ideas in the classroom."*

For this reason, researchers provided friendly and safely environment for discussion with more encouragements. Therefore, Pre-service teachers felt more comfortable to present the results of their study, project outlines and reports on progress in their project to their friends and project's advisors. During the presentation, researcher found that most students (14 people) were enthusiastic to learn and work with other friends. They together helped thinking and planning. Pre-service teachers had many friendly advices from friends and teachers. They learned their advantages and weakness of their work and quickly developed their project by improving form their mistakes. They knew how to solve the urgent problems as a quote in pre-service teacher's journal stated that *"When I presented my project's report progress, there were many things that I did not think about them. I received knowledge and methods from discussion. It was good and gave us knowledge and the way to improve our project. Different perspective of the individual made the project a more complete."* Or a quote in pre-service teacher's journal stated that *"I learned that discussions were very helpful. Thinking alone was only one side of our thinking. Sharing with other people would help to promote the idea. For example, our group got better idea from friends and teachers which led us a direction to do our project. I learned projects progression on other groups. It had problems and obstacle. Some group did not have experiment. Some group did not have knowledge. Every group tried to find a solution. I believed if we could pass these, we win the battle in our mind and proud of ourselves."* From informal interview of pre-service teachers in journals, researcher found that learning by discussion about students' data or questions helped students themselves understood or had correct knowledge because they could answer, gave examples, and compared until they had the same understanding. Pre-service teachers liked and enjoyed this learning atmosphere as a quote in journal said that *"Learning in this class was the most fun that I ever had because everyone had a chance to express and exchange idea with friends and teachers, learning environment was so happy."*

6. Conclusions and Discussions

This research provided data about effective practices and guides the preparation of high quality pre-service science teachers. Researcher found that most of pre-service teachers had bad attitude towards science before learning in Science Project course because they were not interested in what they had done and had less experience of doing project. They thought doing science project was difficult. It took time and it was difficult to understand. Pre-service teachers did not have or had less experience doing science project and did not truly understand how to do the projects. These were problems not to be success, proud to do science project. Also, it made pre-service teachers did not have inspiration to transfer their knowledge to students in the future. Because pre-service lacked of experience in doing science project, they could not discuss their knowledge and understanding about project. Most of them talked about problems occurred in science project that they had experienced in the past. Pre-service teachers only asked knowledge from teacher. They did not research data which made them were uncomfortable to express their idea. Therefore they did not learn from classroom discussion. These findings were similar to Koballa & Glynn (2007) found that students' science learning experiences affect their attitudes. In addition, the quality of science teaching is an important factor affecting students' attitudes toward school science (Osborne, Simon, & Collins, 2003).

However, this study found that learning with project-based teaching by providing examples of science project that link to many disciplines helped them learned to read and ask questions. Also, they analyzed advantages and disadvantages in the projects and used them as a guideline for their projects which affected to change to positive attitude towards science project. In the same way that Chotinun (1981) found that people who had scientific attitude would search knowledge as scientists did, have positive attitudes towards science and scientific activities, have willingness to participate in science activities, and use scientific methods to solve problems.

Moreover, the opportunity for pre-service teachers to hand on their own projects as scientists helped them to have positive attitude toward science project and helped them to understand science project procedures and could use scientific methods to solve the problem. The same as Dosch (1998) founded that doing project was distinction which encouraged students to apply their content knowledge and process skill to integrate to other disciplines. It allowed students to develop a deep understanding in the topics they studied. The direct experiences from attending

the science project contest helped they were enthusiastic about doing project. Therefore, the findings of this study confirm the notion that direct experience in teaching is a key element in a teacher education program (Sadler, 2006). Furthermore, Papastergiou (2005) investigated a project-based learning environment and its impact on student teachers. The research indicated that this approach has been motivational and effective regarding the acquisition of design and development skills. The participants became more interested in and self-confident about project subject, although they encountered certain difficulties.

To promote pre-service science teachers attitude towards science, researchers also supported them to present and have many friendly discussions in a classroom which helped pre-service teachers changing rapidly their attitudes towards science project to be positive. They also learned by themselves and were comfortable to express their idea. Pre-service teachers learned to listen to other people's ideas which helped them to get a variety of knowledge and suggestions for improving their projects until succeeded. Likewise, Haladyna et al. (1983) found that classroom environment was an important element that could change students' attitudes to be positive or negative. Therefore, teachers needed to support learning environment in the classroom.

7. Recommendations

From the result of development of attitudes towards science of pre-service science teachers in the division of science teaching using project-based teaching which could improve students' attitudes, researcher suggested that teachers who take a responsibility for students learning and people who involved in teachers' education should use best practices of project-based teaching approach to classroom in order to help pre-service science teachers have the positive attitude towards science. Further research could investigate how pre-service science teachers apply knowledge about science project when they teach at the school.

References

- Bottoms, G. & L. D. Webb (1998). *Connecting the curriculum to real life and breaking ranks: Making it happen*. Reston, VA: National Association of Secondary School Principals.
- Blumenfeld, P., E. Soloway, R. Marx, J. Krajcik, M. Guzdial, & A. Palincsar (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3-4), 369-398.
- Boonsit, S. (2004). *Study effects of using the science project approach on science learning achievement of Prathomsuksa IV students at Banmuengkornsai in Udornthani*. Master Thesis, Sukhothai Thammathirat Open University.
- Buck Institute for Education (1999). *PBL Overview*. Retrieved date from <http://bie.org/stw/index.html>, July 21, 2013.
- Chotinun, N. (1981). *The relationship between science journal reading and the scientific attitudes and between science journal reading and the attitudes towards science of the upper secondary school students in Bangkok Metropolis*. Bangkok: Dissertation, Graduate School, Chulalongkorn University.
- Crotty, M. (1998). *The Foundations of Social Research: Meaning and Perspective in the Research Process*. 1st ed. Australia: Allen & Unwin.
- Dosch, L. (1998). *Lynn's Learning Pages*. Retrieved date from <http://www.inform.nsk.k12.mn.us/%7eldosch2/pbl/pblexamples/>, June 13, 2013.
- Faknuam, S. 1997. *Comparative study on creative thinking in science and integrated science process skills between Mathayom Suksa III students participating and non participating in science projects*. Master Thesis, Sukhothai Thammathirat Open University.
- Gallagher, J. J. (1991). Uses of interpretive research in science education. In J. J. Gallagher. (ed.). *Interpretive Research in Science Education*. NARST Monograph 4, 5-17.
- Gardner, P.L. (1975). Attitudes to science: A review. *Studies in Science Education*, 2(1): 1-41.
- Haladyna, T., R. Olsen, & J. Shaughnessy (1983). Correlation of class attitude toward science. *Journal of Research in Science Teaching*, 20(4): 311-324.
- Koballa T. R. & S. M. Glynn (2007). Attitudinal and motivational constructs. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research science education*. Englewood cliffs, NJ: Erlbaum Publishers.
- Muellerleile J. (2005). *Attitude VS. Aptitude*. Retrieved date from http://www.4vqp.com/images/062305Attitude_vs_Aptitude.pdf, October 6, 2013.
- Nuansang, N. (1991). *Factors affecting attitude toward science of mathayomsuksa I students in Changwat Samutprakarn*. Dissertation, Graduate School, Kasetsart University.
- NYC department of Education. (2009). *Project-Based Learning: Inspiring Middle School Students to Engage in Deep and Active Learning*. Retrieved date from <http://lincoln.sd74.org/home/sites/lincoln.sd74.org/files/projectbasedlearning.pdf> September 21, 2014.
- Office of the Education Council (OEC). (2000). *Learning Reform: Learner-Centered Approach*. Bangkok: OEC.
- Office of the National Education Commission (ONEC). (2003). *National Education Act B.E. 2542 (1999) and Amendments (Second National Education Act B.E. 2545 (2002))*. Bangkok: Pimdeekanpim Co., Ltd.

- Osborne J, S. Simon & S. Collins (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Research in Science Education*, 25(9): 1049-1079.
- Onocha C. O. (1985). *Patterns of Relationships between Home and school factors and pupils' learning outcomes in Bendel primary science project*. Ph.D Thesis. University of Ibadan, Ibadan.
- Papastergiou, M. (2005). Learning to Design and Implement Educational Web Sites within Pre-Service Training: A Project-Based Learning Environment and Its Impact on Student Teachers. *Learning, Media and Technology*, 30(3), 263–279.
- Partnership for 21st Century Skills. (2009). *P21 Framework Definitions*. Retrieved date from <http://www.p21.org/storage/documents/P21-Framework-Definitions.pdf>, November 18, 2012.
- Samran S. (1999). *Learning achievement, science process skill, and scientific creativity of Muttayomsuksa II students as a result of science project activities*. Master of Education (Science Education), Khon Kaen University.
- Sadler, T. D. (2006). "I wound not last three weeks": Pre-service science teachers reflect on their student-teaching experiences. *Journal of Science Teacher Education*, 17(3), 217-241.
- Tagoolrad S. (2004). *The comparison between science learning outcomes of fifth-grade students studying with the science project approach and the normal teaching approach*. Master Thesis, Nakhon Pathom Rajabhat University.
- The Institute for Promotion of Teaching Science and Technology (IPST). 2008. *The Manual of Science Learning Management under the Basic Education Curriculum B.E. 2551*. Bangkok: Karusapa Press.