The effects of problem based learning for enhancing science problem solving skills

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Abstract. The purpose of this study was to examine the effectiveness of traditional versus problem based learning on high school Science Problem Solving skill. Two class of students were recruited from three classes of grade 7 students at one school in Northern Thailand. Using Pretest – Posttest Control Group Design, students were assigned to an experimental (N=33) and a control (N=33). The research instruments were 1) Two pedagogical lesson plans by using Problem Based Learning and 5E Model 2) The Science Problem Solving skill tests which were included 20 items of the multiple choice test. The finding showed that students’ Science Problem Solving skill in the experimental group were significantly higher than in the control group.

1. Introduction
Science plays an important role in our present and future world communities, as it concerns all of us in our daily lives and livelihoods. Science also involves technologies, instruments, devices and various products at our disposal, which facilitate our life and work. All these benefit from our scientific knowledge, which is combined with creativity as well as other disciplines. Science enables us to develop our thinking skills in various respects logical, creative, analytical and critical. It also enables us to acquire essential investigative skills for seeking knowledge, and allows the ability for systematic problem solving, and for verifiable decision making based on diverse data and evidences. Science is essential to the modern world, which is intrinsically a knowledge society. All of us therefore need to be provided with scientific knowledge so as acquire knowledge and understanding of nature and man-made technologies that can be applied through logical, creative and moral approaches. The basic education core curriculum [10] It enables a person to acquire skills in creativity, logic and systematic and methodical thinking, and allows one to carefully and thoroughly analyze various problems or situations, anticipate, plan, make decisions, solve problems and accurately and appropriately apply sciences in daily life. Sciences serve as a tool for learning science, technology and other disciplines. It is therefore useful to one’s life, enhances quality of life and enables a person to live in harmony with others. Ministry of Education [8] Aside from having knowledge and understanding of the content, students can apply scientific process skills in daily life and further their studies effectively.

The evaluation results of the International Student Assessment Program found that Thailand is experiencing significant problems in educational management that causes students "cannot solve
problems” or “do not like to think critically” Most students lack of Science competency resulting in students are not able to apply science knowledge to use in daily life. Institute for the Promotion of Teaching Science and Technology [5] and the results of assessing science literacy of students in the PISA project. From the information and reasoning, it can be seen that problem based learning instruction is another way to help develop science literacy problems and strengthen the ability to enhance problems solving, regarding local environment and know how to apply knowledge that is used in daily life, including as a guideline for managing teaching Sciences activities to be effectiveness.

2. Literature
2.1 Problem Based Learning
Problem Based Learning is a model based on the concept of constructivist learning theory. In which the learners create new knowledge from the use of intelligence that occurs in the real world as a context. In order for students to develop skills in critical thinking and problem solving Including obtaining the knowledge according to the science in the field of study. [1] The problem based learning is a result of work processes that rely mainly on understanding and problem solving. Schmidt [15] given the good definition of Problem Based Learning that Student observe situations discuss and elaborate with process. It is the development of teaching and learning curriculum in which students have the opportunity to face real problems in life. Its focused, experiential learning organized around the investigation, explanation, and resolution of meaningful problems. [3]
There are several Problem Based Learning approach that adopted by many field sciences the common model design was include with 3 important steps; Step 1: Understand the problem. Step 2: Explore the curriculum. Step 3: Resolve the problem. Students must evaluate their performance and plan improvements for the next problem. can be found in Figure 1.

![Figure 1](image-url)

**Figure 1** Adopted Problem Based Teaching and Learning approach.

2.2 Science Problem Solving skill
Problem solving has important roles in building the capacity of students’ thinking skill and make science teaching become more joyful. It is able to motivate students to have more achievement. By using knowledge of science to solve surrounding environments in daily life. The learning model helps students improve thinking skill and intellectual skill. It is also helps them improve cooperating skill and their students’ social attitude. [9] Because using real problems that found in surrounding environment so it can be used as the basic to gain knowledge and concepts through critical thinking skill. There are four stages of problem solving skill adopted from Serap Caliskan, Gamze Sezgin Selcuk, Mustafa Erol [16] include 4 steps with; 1) define the problem, 2) determine the causes of the
problem, 3) propose the solution, 4) check the solution. Problem solving in science is a process to find a combination that can be applied in an effort to cope with the new situation. The problem solving capabilities are presented in Table 1 and Table 2.

**Table 1** Description of The Problem Solving sub-scales.

| Sub-scales                  | description                                                                 |
|-----------------------------|-----------------------------------------------------------------------------|
| Define the problem          | Rereading the problem. Paraphrasing the problem. Visualizing the problem.     |
|                             | Imagining the problem. Identifying the constraints. Determining the          |
|                             | significant information. Making a simpler problem. Using the appropriate     |
|                             | vocabulary.                                                                 |
| Determine the causes of the | Thinking aloud the solution of the problem. Creating alternative solution     |
| problem                     | ways. Identifying the principles. Rules and laws about the problem.          |
|                             | Dividing the problem into sub-problems. looking for patterns.               |
| Propose the solution         | election of an appropriate solution. Using the rules. Using the scientific   |
|                             | method to solve the problem. Using trial and error.                         |
| Check the solution           | Checking the problem solving pathway. Checking the answer.                   |
|                             | Checking the answer evaluating the result.                                   |

**Table 2** Grid of Problem Solving.

| Aspect                        | Question’s number |
|-------------------------------|-------------------|
| Define the problem            | 1, 6, 11, 16       |
| Determine the causes of the   | 2, 3, 7, 8, 12, 13, 17, 18 |
| problem                       |                   |
| Propose the solution          | 4, 9, 14, 19       |
| Check the solution            | 5, 10, 15, 20      |

3. Data

3.1 Design and participants

The study was based on a 2 pedagogical condition: (experimental and traditional) (time of measure ; pretest posttest design). Participants’ Science Problem solving skill. Were measured both before and after interventions. The participants consist of 66 grade 7 students from Pracharatthammakoon school Ngaow , Lampang, Thailand. The experimental sample group were 33 students from class 1/3 and the traditional sample group were 33 students from class 1/2 selected by simple random sampling.

3.2 Measures

We administered problem solving skill test. That include 1) Define the problem 2) Determine the causes of the problem 3) Propose the solution 4) Check the solution. Sciences problem solving skill test was examine by three experts science educators in term of Index of objective congruence (IOC) Rovinelli , R.J. & Hambleton, R.K. [12] and was evaluated for Internal Consistency Reliability (KR – 20) (Kuder, G. F., & Richardson, M.W. [7][2]

3.3 Sciences Problem Solving skill test

Was a multiple-choice test and contain questions that were typically found in standard school examinations. All test questions (30 items) were evaluated for validity by three experts science educators. Some item were deleted based on their expert judgment. The final version contained 20 test questions (KR-20 = 0.5667)

3.4 Pedagogical intervention

We developed Science content lesson plans which took about 13 hours: one for the experimental and the other for the traditional conditions.
Table 3. Content of lesson plan.

| Content               | Hours |
|-----------------------|-------|
| Atmosphere Condition  | 4     |
| Climate Change        | 5     |
| Weather Forecast      | 4     |

The experimental condition consisted of 6 steps.

1) To determine the problems, the teacher proposed situations related to the content to be used to stimulate learning. Which is the stage where the instructor arranges various situations. Stimulate the students’ interest and seeing problems. After that, teachers divided the groups into 5-6 students.

2) Understand the problem, the group members must present the idea to the problem in terms of determining what the problem is and ways to solve problems. In which the students must understand the problems. A group of students must explain things related to the problem. Because in one of the initial problems the teacher proposed. There may be further sub-problems depending on the problem analysis or group understanding.

3) Define the problem, the learners group together analyzed the problem and set the method or guideline to find the answer that is in accordance with the problem, consisting of the students have to share the issues that need to study and plan the operation steps as follows;

   3.1 Facts from a problem are information that appears in a situation or problem
   3.2 The issue that has to be studied further is the information that must be applied to solve problems that students do not know yet.
   3.3 Methods of study are methods that are conducted in order to obtain the desired knowledge or information.

4) Researching. Each member of the group is responsible for acquiring additional knowledge from outside the group. Which can be obtained from various data sources that the teacher has specified. Which the study can be done as a group or individually. In the study, the group members must study thoroughly to understand. Can explain to other members to understand.

5) Investigate solution where students use their knowledge to exchange, discuss, and synthesize results within the group. Whether the acquired knowledge is appropriate or not.

6) Present and review solution by each group of students summarizes the work of their own group and assess the results of the research that is appropriate or not. By trying to independently examine the ideas within his group. All groups help each other to summarize the knowledge in the overview of the problem again, consisting of presentations or solutions. Which will propose the plans of all groups. And will allow students in the class to assess the work of other groups as well. Finally, teachers and students will help summarize the information or knowledge that each group has researched again.

Table 4 Comparison of Problem-Based Learning step with Science problem solving step.

| PBL pedagogical step       | Science Problem solving step                  |
|----------------------------|-----------------------------------------------|
| Step 1 Problem determination| Step 1 Define the problem                      |
| Step 2 Understand the problem| Step 2 Determine the causes of the problem   |
| Step 3 Define the problem  | Step 3 Propose the solution                   |
| Step 4 Research            | Step 4 Check the solution                     |
| Step 5 Investigate solution|                                               |
| Step 6 Presentation and review solution |               |

In the traditional pedagogical condition, consisted of 5 step;

1) Teacher works to gain an understanding of the students’ prior knowledge and identify any knowledge gaps. To foster students’ interest and the upcoming concepts that students will be ready to learn. She asks students with asking opening questions what they already know about the topic.

2) Students explore the new concept through concrete learning experiences. Teacher asked to go through the scientific method and communicate with their peers to make observations.
3) The teacher helps students synthesize new knowledge and ask questions if they need further clarification. She asks students to share what they learned during the explore phase before introducing technical information in a more direct manner.
4) The elaboration phase focuses on giving students space to apply what they’ve learned. To develop a deeper understanding. She asks students to create presentations to reinforce new skills for cement their knowledge before evaluation.
5) Teachers observe their students and see whether they have a complete grasp of the core concepts with an exam assessment.

Table 5 Comparison of 5E Learning step with Science problem solving step.

| 5E pedagogical step | Science Problem solving step |
|---------------------|-----------------------------|
| Step 1 Engagement   | Step 1 Define the problem   |
| Step 2 Exploration  | Step 2 Determine the causes of the problem |
| Step 3 Explanation  | Step 3 Propose the solution |
| Step 4 Elaboration  | Step 4 Check the solution   |
| Step 5 Evaluation   |                             |

The procedure and the sequence in which instruments were administered can be found in Figure 2.

![Figure 2. Procedure.](image)

4. Results
Evaluations of pre-test and post-test performance in Science Problem Solving skill showed that though students in both conditions improved, students in the experimental condition enhance more than did those in traditional conditions. It is found that the learning styles have effective on Students’ Problem Solving skills. With statistical significance at the level of 0.01
Table 6. Comparison of differences in performance between Science Problem Solving pedagogical at pre-test and post-test.

|                      | Experimental Group (n=33) | Traditional Group (n=33) | t     |
|----------------------|---------------------------|--------------------------|-------|
|                      | mean          | s.d.          | mean          | s.d.  |       |
| **Step 1** : Define the problem (range = 0-4) |              |               |              |       |       |
| Pre-test             | 1.091         | 0.879         | 0.333         | 0.540 | 4.218**|
| Post-test            | 2.424         | 0.663         | 1.576         | 0.867 | 4.466**|
| t                    | -8.608**      | -7.130**      |               |       |       |
| **Step 2** : Determine the clauses of problem (range = 0-8) |              |               |              |       |       |
| Pre-test             | 2.394         | 1.321         | 1.424         | 1.200 | 3.121**|
| Post-test            | 6.000         | 1.225         | 3.121         | 1.023 | 10.361**|
| t                    | -10.282**     | -6.369**      |               |       |       |
| **Step 3** : Propose the solution (range = 0-4) |              |               |              |       |       |
| Pre-test             | 1.091         | 0.805         | 0.636         | 0.742 | 2.385* |
| Post-test            | 2.848         | 0.834         | 1.333         | 0.816 | 7.459**|
| t                    | -8.807**      | -3.725**      |               |       |       |
| **Step 4** : Check the solution (range = 0-4) |              |               |              |       |       |
| Pre-test             | 1.152         | 0.795         | 0.667         | 0.595 | 2.804**|
| Post-test            | 3.273         | 0.626         | 2.212         | 1.083 | 4.871**|
| t                    | -11.567**     | -6.700**      |               |       |       |

** p < .01 ; * p < .05

5. Discussion

The data shown that the experimental condition enhanced problem solving skill more than did the traditional pedagogical condition. Students in the tradition still showed significant improvement; just not as much. With our experimental condition similar to problem based and the traditional condition more similar to structured pedagogies, these findings are effect than 5E approaches in promoting science learning. Consistent with the research of using the problem based teaching model combined with the creation of a learning experience by using the situation and its surroundings as an important issue in determining problems. As well as a stimulating process that focuses on the students to look at problems, analyze and exchange knowledge together. Will make a lot of learning development and durable knowledge. Shows that the ability to solve problems is an important product resulting from learning. It is characterized by skills that are deeply embedded rather than achievement. Knowledge is the ability to solve problems, an important skill resulting from repeated learning and practice until it becomes proficient and will requires for increase experience. According to Jumaita NoprianiLubis, Asmin Panjaitan, Edy Surya, Edy Syahputra [6] Analysis Mathematical Problem Solving Skills of Student of the Grade VIII-2 Junior High School Bilah Hulu Labuhan Batu presented that mathematical problem solving abilities consist of four basic steps namely; understand the problem, devising a plan, carry out the plan, re-examine the results obtained. Almost the same as science problem solving skill. Supporting with Ijirana, Lukman Nadjamuddin [4] Which has studied Time Series Study of Problem Solving Ability of Tadulako University Student Using Metacognitive Skill Based Learning Model, The result was shown that the model has not been success to improve students’ ability well. Nevertheless, Students at both classes is the growth in score of science literacy and knowledge. In addition there are several factors influencing toward the study consist of time, individual ability, learning quality, environment factor. The research process require not a short time, hence it should be continuously to frequency the learning process.

6. Conclusions and implications

The findings of this study, it was concluded that students’ measure of problem based learning and 5E model are both influential factor in problem solving skills of science. Students’ problem solving skill in traditional group increasing their solving skill like experimental group and not different much more. This could be due to some other factors either on the part of the students, teachers or environment of the study among others. Saul McLeod [14] said from Piaget’s theory that cognitive development was a progressive reorganization of mental processes as a result of biological maturation.
and environmental experience. Children construct an understanding of the world around them, then experience discrepancies between what they already know and what they discover in their environment. And the learning process permeates through the brain experience. Which the brain will adjust the old experience and new experience together Therefore, teaching methods should use concrete things. For children to understand concepts that will lead to systematically blending knowledge talking about whole is better than talking about part, such as presenting the result of the problem first and having the student analyze the cause of the problem show that public matter knowledgeable the subsections are characterized as problem solving skills. These things happen together and the process skills will be deeply rooted knowledge. More than achievement and when the student interacts with the environment in the face of problem solving will promote intellectual development for the learners according with Sanit Srikoon had study the comparison of Research Based Learning and Inquiry learning instruction for develop Science achievement found that the detection and discrimination skills in Research Based Learning tents to increasing cognitive processing and effect on working memory and attention more than the normal learning group. Therefore, it can be concluded that the development of problem solving ability will be more effective than the development of achievement.

According to Pavinee Sothayapetch, Jari Lavonen, Kalle Juuti[11] said that Thai Science curriculum was similar to the PISA framework has focused on 5E model. That aim for empathize scientific process and finish the curriculum concepts. Different from others Europe countries that aim for thinking process from contextualize based and social participation. Based on the study, the following recommendations were made:

1. Science teachers should concentration on student center based important for learning experiences that require creative Problem Solving skills.
2. Science teachers need to working hard in preparing lesson plan for acquire necessary skills on building up of students’ Problem Solving skill.
3. Science teachers should focus on differences between students, Student’s behavior and teaching Science including authentic assessment.

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