

A Study of Problems and Needs in Teaching in a Virtual Science Lab to Develop Middle School Students' Analytical Thinking Skills

Unchana Klentien^(✉) and Wannachai Wannasawade

Department of Computer Education, Faculty of Technical Education,
King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
unapor@gmail.com

Abstract. This research examined problems and needs of Thai teachers teaching in a virtual Science lab to develop middle school students' analytical thinking skills. Data was collected from 400 teachers under the Office of Basic Education Commission (OBEC), Ministry of Education, through a set of questionnaire. The sampling group was selected through multi-stage randomization and simple random sampling. The survey questionnaire consisted of closed-ended questions with a checklist and rating scale and open-ended questions. The findings from the study indicated that the major problem for teaching Science is the lack of multimedia and teaching equipment in a Science lab. Limited budget in setting up a Science lab is also an issue. In order to teach in a virtual Science lab to develop middle school students' analytical thinking skills, Blended Learning, which includes conventional classroom and online learning, was chosen to be the most appropriate model. A virtual Science lab should resemble an actual Science lab as much as possible, which includes having tables, a scene, Science equipment, and should accommodate both online and offline learning. Hardware and software should be adequate for the number of students, so they can learn and interact effectively. The program should be interactive and designed for group learning, with a 'Help' function to allow students to learn and solve problems by themselves. The recommended duration for each lesson should be 1–2 h.

Keywords: Virtual science lab · Analytical thinking skills · Middle school

1 Introduction

Thailand is currently quite active in becoming a part of ASEAN community, particularly in the education sector where there are efforts to improve the quality of Thai students and Thai education to compete with other ASEAN countries, whether it is academic knowledge, language skills, or analytical thinking, which is particularly the essence of human development. Consequently, every sector must promptly take action to develop teachers, so that they can use a variety of activities to teach in order to foster schools and students' surroundings to function like a lab to develop such skills.

Teachers and school administrators agree that current teaching methods only transfer knowledge to students through textbooks, but cannot help students develop analytical

thinking skills, while it has been a crucial part of education reform regardless of which era it is. In the 21st century, learner development in many countries focuses on analytical thinking, creative thinking, occupational skills, life skills, ICT skills, and communication skills [1]. Science is a subject that helps human beings develop their way of thinking, which involves logical thinking, creative thinking, analytical thinking, and critiquing. In addition, Science promotes researching skills, systematic problem solving, and decision making based on a variety of information sources and evidence that can be proved. Science enables learners to learn Science while connecting knowledge with process, and to develop research skills while creating knowledge through searching for information and solving problems. Learners are actively involved in every process of learning, and in a variety of hands-on activities that are suitable for every grade level [2].

A number of educators have used teaching methods that foster analytical thinking skills, for instance, Kaewkoy [3] conducted research on the effects of virtual laboratory with guided inquiry-based learning upon learning achievement in Physics of tenth grade students. The results illustrated that the students' achievement was improved. Chulasewok [4] also argued that analytical thinking skill is an intellectual skill that is more advanced than understanding and application. Analytical thinking skill is the ability to distinguish any given topic into sections, by component, relation and principle - through a variety of media - and establishing relationships between each part of the information in order to understand a notion or the relationship between notions through using scientific methods, which start from a question of interest on the learner's part, gathering data, experimenting and synthesizing data from evidence before drawing a conclusion. Organizing experiment activities in a Science lab is also a learning activity in which students must explore for answers through scientific methods.

As mentioned earlier, the researcher is aware of the importance of developing middle school students' analytical thinking skills; therefore, this study of problems and needs in teaching in a virtual Science lab to develop middle school students' analytical thinking skills was conducted. The objective of the study is to examine challenges in teaching Science and identify needs in teaching in a virtual Science lab, which will be a model for teaching Science classes effectively in the future.

2 Research Objectives

To study problems and needs in teaching in a virtual Science lab to develop middle school students' analytical thinking skills.

3 Method

The study problems and needs in teaching in a virtual Science lab to develop middle school students' analytical thinking skills, the researcher followed these steps:

3.1 Literature Review

Review documents and research relevant to teaching Science classes in a virtual Science lab, and study factors that affect teaching/learning Science in a Science lab.

3.2 Selection of Sampling Group for This Study

The sampling group included 400 Science teachers who taught middle school in schools under the Office of Basic Education Commission (OBEC), Ministry of Education. This group was selected through a multi-stage randomization method, choosing representatives from each Secondary Education Service Area, and through a simple random sampling method, choosing Science teachers to be the sampling group for this study.

3.3 Developing Research Tool

The research tool was a questionnaire regarding problems and needs in teaching in a virtual Science lab to develop middle school students' analytical thinking skills. The questionnaire was developed from relevant document and research. It consists of 4 parts:

- Part 1: Basic information on the participants.
- Part 2: A survey on general conditions of teaching Science and problems in teaching.
- Part 3: A survey on needs in teaching Science to develop middle school students' analytical thinking skills.
- Part 4: A survey on learning in a virtual Science lab to develop middle school students' analytical thinking skills.

3.4 Data Collection

The researcher sent out questionnaires to schools throughout the country under the Office of Basic Education Commission (OBEC), Ministry of Education. The duration of the data collection stage was two months.

3.5 Data Analysis

After data has been collected, the researcher analyzed the data by using statistics, percentage, average mean, and standard deviation.

4 Research Results

The results from the study of problems and needs in teaching in a virtual Science lab to develop middle school students' analytical thinking skills are as follows:

4.1 Basic Information on the Participants

The majority of teachers who specialize in teaching Science are female. (288 teachers; 72%) The rest are male, respectively. (112 teachers; 28%) Most of these Science teachers have a Bachelor's Degree (205 teachers; 51.25%); while the next largest group have a Master's Degree (190 teachers; 47.50%), and the rest have a Doctor's of Philosophy Degree (4 teachers; 1%), and other degrees (1 teacher; 0,25%), respectively. As for the school size, most of them (180 teachers; 45%) teach in mid-sized secondary schools with 121–600 students; the next group (98 teachers; 24.50%) teach in extra large schools with 1,500 students; the following group (90 teachers; 22.50%) teach in large schools with 601–1,500 students; and the last group (32 teachers; 8%) teach in small schools with 1–120 students, respectively.

4.2 General Conditions of Teaching Science in Middle School Level

The sampling group of 400 science teachers who are teaching in middle schools under the Office of Basic Education Commission (OBEC), Ministry of Education gave suggestion about teaching science in middle schools as following:

Teachers. Problems and obstacles in teaching Science can be identified as follows: Most of the teachers have other responsibilities besides teaching; therefore, their teaching efficiency is lowered. In addition, they also have excessive teaching load, which results in lack of time for self-development. As for resources the teachers use for lesson-planning, most of them search information on the internet and relevant database, books, textbooks, and other documents collected.

Learners. Problems and obstacles in learning Science can be identified as follows: In most cases, students have different background knowledge, both scientifically and mathematically. In addition, they lack methodical scientific processes; therefore, they are not as interested in learning Science as they should be. In terms of learner behavior, those who are the least participatory cannot plan on their own and depend on instructions from teachers. In addition, they dislike written examination and dislike scientific experiments because their lack of background knowledge, skills, and other qualifications on the learners' part, which include basic calculation skills, analytical thinking skills, scientific skills, and the ability to create a project.

Teaching Activities. Problems and obstacles in teaching Science can be identified as follows: Learners are not as cooperative of the activities as they are expected to be. In addition, there is a lack of budget and shortage of teaching aid/materials. Most of the teaching is done through lectures, followed by information searches, demonstrations and experiments, respectively. When asked if teaching involved developing students'

analytical thinking skills, the Science teachers responded that their teaching involved developing students' analytical thinking skills through setting a question, then allowing learners to search for solutions on their own. The next approach used is teaching the content partially and having learners practice their analytical thinking skills, then, experiment in a real situation.

Teaching Materials and Learning Resources. Problems and obstacles in teaching Science can be identified as follows: Most teachers lack teaching materials and equipment in their Science lab, which include basic chemical substances used in experiments. In addition, the school lacks budget to set up a Science lab. Science teachers use some teaching materials, but not every time they teach. If they have to produce their own teaching material, they will use existing resources in daily life or create something based on the budget allocated. The most frequent resource they use are textbooks, but sometimes they use the internet and some other electronic media to supplement their lessons, which involve media to present the content of the subject matter (in lieu of lectures) and to communicate between teacher-learners and learners-learners.

Assessment and Evaluation. Problems and obstacles in teaching Science can be identified as follows: Most learners lack writing skills, consequently, they cannot complete written examinations. Moreover, most of the assessment is done through an examination, which cannot actually assess the learners' knowledge and ability. In terms of assessment, most teachers focus on the learners' attention and participation in class, while most course objectives emphasize on the learners' understanding and application.

Needs in Teaching Science to Develop Middle School Students' Analytical Thinking Skills. The needs assessment in teaching in a virtual Science lab to develop middle school students' analytical thinking skills indicated that Blended Learning should be used, which means learning should take place in both a conventional classroom and online. As for learner grouping, the learners should group themselves without having conditions. The appropriate group size should be from 2–4 learners. In order to teach while developing the learners' analytical thinking skill, the questions used should be within context, and the learners should identify the questions they want to work on by themselves. The factors that affect the learners' analytical thinking skills are past and personal experience. Evaluation and assessment should be based on the success of each project, to foster the learners' analytical thinking skills. Topics that are suitable for developing middle school students' analytical thinking skills include electric energy, friction, and plants, respectively.

4.3 Data on Teaching in a Virtual Science Lab to Develop Middle School Students' Analytical Thinking Skills

The sampling group of 400 science teachers who are teaching in middle schools under the Office of Basic Education Commission (OBEC), Ministry of Education gave suggestion about virtual Science lab to develop middle school students' analytical thinking skills as following:

Table 1. Summary about virtual Science lab to develop middle school students’ analytical thinking skills

Topic/issue	Suggestions
(1) Appropriate virtual Science lab	<ul style="list-style-type: none"> - Blended Learning should be applied, which includes conventional classroom set-up and online learning, experiments, and project-based learning. Learners should identify a question, come up with a hypothesis, conduct experiments and draw conclusions on their own, under the supervision of teachers. There should also be a forum to express opinions, to participate as a group learning experience, to interact with textbooks, to think analytically, and to discuss the learning process - Use situations to explore questions together and demonstrate how to think analytically - The lessons should be appropriate to the learners’ potential and nature, while stimulating and creating interest among the learners through a variety of topics <p>Students should be allowed to search for knowledge and ideas on their own, with the teachers present as their observer and advisor</p> <ul style="list-style-type: none"> - Additional searches (outside the classroom/lab) should be facilitated in order to obtain more knowledge. Then, the information should be applied to a project-based learning. An appropriate Science lab should have tables that accommodate groups of 3–5, be equipped with internet, and have a teacher present as an advisor
(2) Scene and equipment in a virtual Science lab	<ul style="list-style-type: none"> - The scene should be interesting and as real as possible. (This could be a 3D picture). Experiment tools should look real and have the same color as the real ones - Equipment should be ready and convenient to use, with directions and signage for instructions. They should be colorful to stimulate learning. The equipment should be relevant to the content of the lesson and the learning process - The scene should be interesting, inviting, and challenging to learners, so that they want to participate in the upcoming simulation and can prepare themselves to face obstacles and have determination to overcome problems - Scenes should be simple, have warm tones that are friendly to the eyes, and have color gradation - Scenes should be changeable, colorful, relevant to Science, and should reflect the topic in the lesson.

(continued)

Table 1. (continued)

Topic/issue	Suggestions
	Equipment should be relevant to Science. Pictures used should be relevant to the topic. Equipment used in the lab for each activity should be organized and come with instructions
(3) Duration of class in a virtual Science lab	- 1–2 h - Depends on each topic - Flexible, depending on activity
(4) How to stimulate learners	- Stimulate their analytical thinking, synthetical thinking, and creative thinking - Stimulate their interests, making them want to participate through exciting activities and vivid visual aid - Stimulate learners' interest to solve problems
(5) Should there be support for the learners during the lesson?	There should be support available for learners so they can obtain additional information. Learners also have different background, and when they have questions, they should get answers within a timely manner. This will also stimulate curiosity, interest, and help their learning become more successful. Support should also be available in case danger arises in the classroom
(6) How should teachers interact with learners?	- Immediate response/feedback, like in a conventional classroom. There should be a communication room to facilitate this - Feedback should be displayed when a process is completed. Signage to explain each point should be available to show or explain when a mistake is made - There should be question-answer between learners
(7) How should feedback be given?	Immediately, and should be positive, such as learners' achievement reflect that the virtual Science lab is similar to learning in a Science lab. If the learners pay attention to the experiment, it will result in a success, which reflects the learners' development. This creates a drive to learn Science, which can be applicable in daily life when they can actually experiment

The findings summarized in Table 1 were analyzed and synthesized from data collected, Based on the needs assessment on teaching in a virtual Science lab to develop middle school students' analytical thinking skills, most Science teachers stated that virtual Science labs should resemble actual Science labs as much as possible. It should accommodate both offline and online learning, have sufficient sets of equipment for learners - so that they can learn on their own and engage in interacting.

Scenes and equipment in the virtual Science lab should be simple, warm-toned, friendly to the eyes, interesting, organized, easy to use, and relevant to the content and to the learning process. As for the recommended duration of class in a virtual Science lab, it should be 1–2 h each time, or should be flexible depending on activity. If learners come across problems during class, there should be resources available and immediate interaction to give them additional information, or assist those with different background. When learners have a question or need advice, and they are able to have their needs met immediately, it enables them to become more successful in learning.

5 Conclusion and Recommendations

The “A study of problems and needs in teaching in a virtual Science lab to develop middle school students’ analytical thinking skills” through a questionnaire distributed to 400 Science teachers in middle schools under the Office of Basic Education Commission (OBEC), Ministry of Education indicated that there is a need in having a virtual Science lab in order to develop middle school students’ analytical thinking skills, because most schools have the issue of learners not being as cooperative and a lack of teaching materials and experiment equipment (or have insufficient sets of equipment). The appropriate teaching method should be Blended Learning, both online and offline, since these Science teachers agreed that offline learning is still crucial within the school context in Thailand, as it allows teachers to monitor the classes closely and to complement each lesson with offline resources. A virtual Science lab should resemble an actual Science lab in every aspect, including the learning environment and equipment that is relevant to the topic. After using the virtual Science lab, learners should be allowed to conduct the experiment in a Science lab or organize a Science project to review and assess their learning process, as opposed to only taking the examination for assessment.

6 Next Phase of the Study

The next phase will be creating a virtual Science lab to develop middle school students’ analytical thinking skills and using the virtual Science lab with actual sampling groups in order to determine from the learners’ achievement whether the lab is relevant or to which level it affects their analytical thinking skills.

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