สภาพการเรียนการสอนวิทยาศาสตร์ตามแนวปฏิรูปหลักสูตรวิทยาศาสตร์ขั้นพื้นฐานในประเทศไทย
The State of Teaching and Learning Science according to Basic Science Curriculum Reform in Thailand

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บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาสภาพการเรียนการสอนวิทยาศาสตร์ตามแนวปฏิรูปหลักสูตรวิทยาศาสตร์ขั้นพื้นฐานตามการรับรู้ของครูวิทยาศาสตร์ นักเรียน และนักวิทยาศาสตร์ศึกษา โดยใช้ระเบียบวิธีวิจัยเชิงสำรวจ กลุ่มตัวอย่างได้จากการสุ่มแบบชั้น ภูมิได้ครูวิทยาศาสตร์ 225 คน นักเรียน 2,250 คน และนักวิทยาศาสตร์ศึกษา 256 คน เครื่องมือในการวิจัยได้แก่แบบสอบถามจำนวน 3 ชุด วิเคราะห์ข้อมูลโดยใช้สถิติเชิงบรรยาย ผลการวิจัยพบว่า สภาพการเรียนการสอนวิทยาศาสตร์เป็นไปตามแนวปฏิรูปหลักสูตรวิทยาศาสตร์ในระดับหนึ่ง โดยมีครูวิทยาศาสตร์บางท่านใช้วิธีสอนตามหลักสูตรวิทยาศาสตร์ขั้นพื้นฐานของสถาบันส่งเสริมการสอนวิทยาศาสตร์และเทคโนโลยี (สสวท.) เพื่อกระตุ้นให้นักเรียนได้รับประสบการณ์ความรู้และกระบวนการต่างๆ และพัฒนาความมีเหตุผล ทักษะการคิดวิจารณญาณและการคิดสร้างสรรค์ของนักเรียน ใช้สื่ออุปกรณ์แบบต่างๆตามหลักสูตรของ สสวท. ใช้วิธีการที่หลากหลายที่บ่งชี้ผลการเรียนรู้ของนักเรียนจากกิจกรรมการเรียนรู้ สำหรับนักเรียนส่วนใหญ่นั้นทำงานเป็นกลุ่มเล็กๆ และนานๆ ครั้งถึงทำโครงงานวิทยาศาสตร์ ใช้เอกสารที่ครูทำขึ้น ใช้แหล่งเรียนรู้จากเว็บไซด์ และใช้หนังสือเรียนวิทยาศาสตร์ นักเรียนรับรู้ว่าครูให้น้ำหนักมากกับการประเมินโดยใช้แบบทดสอบมาตรฐาน แบบทดสอบอัตนัย และแบบทดสอบปรนัย นักวิทยาศาสตร์ศึกษาส่วนใหญ่มีความคิดเห็นทั้งที่สอดคล้องและไม่สอดคล้องกับระดับความเห็นของครูและนักเรียน นอกจากนี้ครูวิทยาศาสตร์และนักวิทยาศาสตร์ศึกษาส่วนใหญ่ต่างเห็นสอดคล้องกันว่า ปัจจัยสำคัญที่มีผลต่อการเรียนรู้วิทยาศาสตร์ในห้องเรียนคือ นักเรียนที่ไม่สนใจเรียน การขาดแคลนอุปกรณ์การเรียนการสอน และอัตราส่วนที่สูงระหว่างนักเรียนต่อครู

Abstract

The objective was to study the state of teaching and learning science under the basic science curriculum reform based on the perceptions of science teachers, their students and science educators. The subjects from this research survey were selected by using a stratified random sampling of 225 science teachers, 2,250 students, and 256 science educators. The instruments used included three questionnaires. The statistics used were

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descriptive statistics. The results show that the state of teaching and learning science is in line with science curriculum reform at a certain level. Some science teachers taught according to the IPST Basic Science Curriculum that encouraged students to experience knowledge and processes and to develop their reasoning, critical thinking and creative thinking skills. Teachers were encouraged to use different types of materials corresponding to the IPST Basic Science Curriculum, and to use various methods to determine the results of student learning from the learning activities. The majority of students worked in small groups and worked on science projects once in a while, used notes and worksheets prepared by the teachers, and used resources from internet websites and science textbooks. Students perceived that teachers gave a great deal of weight to standardized, objective, and subjective tests and the assessment information gathered. The science educators agreed and disagreed with the teachersθ and students' perceptions. However, most science teachers and science educators agreed that the important factors that affect science learning in science classes are uninterested students, a shortage of instructional equipment, and a high student / teacher ratio.

คำสำคัญ: สภาพการเรียนการสอนวิทยาศาสตร์, การปฏิรูปหลักสูตรวิทยาศาสตร์ขั้นพื้นฐาน, ครูวิทยาศาสตร์
Keywords: the state of teaching and learning science, basic science curriculum reform, science teacher

Introduction

Thailand has been implementing educational reforms, specifically learning reforms, which are at the heart of all concerned according to the National Education Act B.E. 2542 (1999). The Act stresses the need for the country to improve the quality of education and to align it with processes that produce citizens who possess capabilities to cope with the rapidly changing world of the 21st century. Of particular importance are students' science, technology, creativity, and learning abilities. The Act recognizes a need for Thai schools to develop new types of knowledge beyond the technical knowledge that is currently emphasized. It also recognizes that this requires new approaches to learning including the student-centered or learner-oriented approach (Office of the National Education Commission, 1999; Sub-Committee on Learning Reform of the National Education Commission, 2000). The aim of the reforms is to develop students to be perfect human beings with good health, wholesome minds, intelligence, knowledge, morality, good behavior, and a rich cultural life (Office of the National Education Commission, 2000).

The National Education Act B.E. 2542 (1999) emphasizes the importance of science and technology, stating that the teaching and learning process should help students to develop their scientific and technological knowledge and skills, as well as knowledge, understanding, and experience in management, conservation, and utilization of natural resources and the environment in a balanced and sustainable manner (Office of the National Education Commission, 2000; p. 10). In addition, organizing the learning process through the learner-centered approach should aim to provide the highest benefits for learners and allow them to develop themselves to the best of their potential, provide them with a variety of sources to acquire knowledge seeking skills, enable them to apply their learning abilities to their daily lives, and allow all those concerned to participate in the learners' development at all stages. In order to accomplish the stated aims, teachers who are at the heart of the learning process must act as facilitators. The teachers should be able to conduct the following effectively: identification of learners' interests and their prior knowledge, preparation of teaching plans, and organization of learning activities and assessment procedures (Sub-Committee on Learning Reform of the National Education Commission, 2000). To ensure that learning reform according to the National Education Act B.E. 2542 would be accomplished, the 2001 Basic Education Curriculum was established.

The Institute for the Promotion of Teaching and Learning Science and Technology (IPST) played a major role in the development of the 2001 Basic Science Curriculum. It set the standards and benchmarks for learning at the basic level, the standards for learning at different levels, and provided core subject matter for basic education. Students were divided into four grade cluster levels: the first grade cluster level (grades 1-3), the second grade cluster level (grades 4-6), the third grade cluster level (grades 7-9), and the fourth grade cluster level (grades 10-12). The science strand consists of concept maps, content for levels and grades, expected learning outcomes, and the content of each grade for successive periods from grade 1 to grade 12. The IPST also provides examples of learning units, descriptions of the basic science courses, and lesson plans. Guidelines for each level in learning management, materials and resources, and assessment are also included in the curriculum. All these comprise the core of the basic education curriculum as stipulated in the National Education Act B.E. 2542 (Office of the Private Administration Commission, 2004).

Before the implementation of the 2002 Basic Science Curriculum, many studies concerning teaching and learning in Thai science classrooms at both elementary and secondary levels revealed that there have been several problems related to both student achievement and teaching practices. The Office of the Education Council (OEC) published the Report on Evaluation of Learning Reform at the Basic Education Level in which desirable qualities of learners in grade 6 and grade 9 were evaluated. The results showed that academic achievement in science was not satisfactory. The evaluation of thinking skills, knowledge-seeking skills, and working skills, such as teamwork, utilization of learning sources, and planning, also revealed unsatisfactory results (Office of the National Education Commission, 2000, 2002). Teacher practices, including teaching methods, learning activities, science materials, and assessment were reported to be at a moderate level. For example, most teachers in schools under the Extension of Educational Opportunity Project in Bangkok had been involved in a training program before the implementation of the curriculum. The teachers performed science teaching skills at a moderate level in terms of lesson planning, conducting learning activities, and management of instructional materials. The teachers mainly used teacher-constructed tests to measure students' achievements (Moeynorata, 1997). The results correspond to the study of the Institute of the Development of Education, Religion, and Culture, Education Area 6 (1998) that explored the state of teaching and learning science using the student-centered approach at the lower secondary level.

The causes of the problems come from the competency and understanding of teachers in learning management, budget shortages and lack of instructional materials, and low student interest in learning (Office of Development of Education, Religion, and Culture, Education Area 6, 1998; Moeynorata, 1997; Office of the National Education Commission, 1999). Teaching loads and other duties that teachers were assigned, class size, inadequate and out of date books and materials, inadequate numbers of computers, and parents' cooperation with teachers in looking after students' learning caused problems in teaching and learning as well (Office of the Private Administration Commission, 2002; Institute for the Promotion of Teaching Science and Technology, 2002a, 2002b). In addition, lack of science equipment, and shortages of qualified teachers have affected the outcome.

The system of entrance examinations to universities is also a major obstacle to effectively teaching and learning science. The testing is intended to emphasize both content and the learning process, but students have demonstrated that they are more interested in passing the examination only as a means to being admitted to a certain university (Boonklurb, 2000).

Teaching and learning science development at all school levels has been conducted as educational reform using a student-centered approach following the National Education Act B.E. 1999. All schools have been using the new science curriculum since 2002. The IPST, which is responsible for teacher and educational personnel, and professional development in science, mathematics, and technology, also ensures that teachers are able to teach according to standards of educational reform in all educational systems. IPST has worked cooperatively with educational institutes in the Ministry of Education to select both elementary and secondary schools in all educational areas since 2002 for school-based teacher development. In addition, IPST joined with an academic network among Faculties of Science in 24 universities throughout the country to develop the quality of learning management in mathematics, science, and technology in 740 schools in 175 educational areas in 76 provinces. The IPST chose 401 schools from 740 schools in a project which aims to develop leader schools in the teaching of science, mathematics, and technology, and to develop learning centers in local areas. The centers would be responsible for teacher development in each educational area in order to help their schools in the area and extend this development to teachers in other schools in Thailand. A follow up study on the state of teaching and learning science from the leader schools would be necessary to provide information for developing science teachers.

After the 2002 Basic Science Curriculum was implemented, it was found that student achievement in terms of knowledge, process skills, and ability to make decisions was still unsatisfactory (Office of the Education Council, 2004). Studying the state of teaching and learning science will help science educators to understand problems in science classrooms and be able to explain clearly how student achievement in science is a result of the way that teachers teach science in the classroom.

Objective

The objective of this study was to explore the state of teaching and learning science in IPST leader secondary schools in Thailand based on the perceptions of science teachers, students, and science educators.

Methodology

The survey research was conducted to study the state of teaching and the learning of science in IPST leader secondary schools in Thailand. Data was collected from science teachers, students, and science educators.

Samples

Samples consisted of 225 science teachers, 2,250 students, and 256 science educators. Stratified random sampling was used to obtain the samples for the study. Forty-five secondary schools out of 401 schools throughout the country were selected to be in the sample group in the study. The schools were attached to three different institutes, which were in the Leader Schools Project of the IPST under the Ministry of Education. The Project aimed to develop the schools as models for other schools in the teaching of science. Twenty-five schools from the Institute of General Education, fifteen schools from the Institute of National Elementary Education Commission, including schools from the Educational Opportunity Extension Program (where the lower secondary education level (grade 7 to grade 9) was established in elementary schools), and five schools from the Institute of Private Education Commission were sampled. Teachers included one science teacher in each grade from grade 7 to grade 9, and three teachers from grade 10, including a physics teacher, a chemistry teacher, a biology teacher, and/or a physical and biological science teacher from each school. The exceptions were the schools under the Institute of National Elementary Education Commission where there were only science teachers from grade 7 to grade 9. Two science educators who were involved in educating pre-service science teachers from each of the Faculties of Education and Faculties of Science of sixty-five universities throughout the country participated in the study. 128 (50.0%) science educators participated in the study.

Instruments

Three questionnaires, including a Science Teacher Questionnaire, a Student Questionnaire, and a Science Educator Questionnaire, were used to survey the science teachers', students', and science educators' perceptions of the state of teaching and learning science in secondary schools. Each questionnaire has two parts and each part has both checklist and fill in the blank format.

The Science Teacher Questionnaire and the Science Educator Questionnaire consisted of two parts: the first part consisted of questions related to background information of the participants including age, gender, education, experience, work load, and associated activities related to teaching and learning science. The second part explored more specifically the participants' perceptions concerning the teaching and learning of science, i.e., planning science lessons, instructional materials used, assessment, and limitations in teaching science. The planning science lessons category included documents and main resources used to develop lesson plans, to conduct different types of science classes, to study learning behaviors of students, to study teaching behaviors related to classroom interaction, and to guide student group work, student homework, and assignments. The instructional materials category included textbooks, educational resources, and computers. Assessment consisted of various types of assessment and using the assessment information. The last category was related to limiting factors related to teaching science.

The Student Questionnaire also consisted of two parts. The first part was about age, gender, grade level, language used at home, computer use, time spent working after school, educational expectations, parents' educational backgrounds, and parents' expectations. The second part was concerned with studentsๆ perceptions about learning in science class including their own learning behavior, factors related to learning science effectively, homework and assignments, instructional materials, and assessment.

The questionnaires were developed by the International Science and Mathematics Project Committee from eight countries including Japan, Singapore, China, Hong Kong, the United States, South Korea, Germany, and Thailand. (The representatives of each country called meetings to designate the framework of the questionnaires to meet research objectives. It was agreed that each country could adapt some of the items to fit their own context. Therefore, some of the items including the level of education and standards were changed to fit the Thai context.) Three researchers, including two science educators and one educational researcher, translated the English versions of the questionnaires into Thai. The questionnaires were tried out with science teachers, students, and science educators.

Data Collection and Analysis

The researchers made a list of the schools sampled and all universities. The questionnaires were mailed to the school and university administrators with cover letters from the IPST asking for permission to distribute the questionnaires to science teachers, students, and science educators, respectively. The data collection was conducted during September and October of 2004. There were 166 science teachers (73.8%) from a total of 225 science teachers who completed the questionnaires. The science teachers were asked to sample ten students from their science classes. Overall, 1,754 students (77.9%) responded to the questionnaires. 128 (50.0%) science educators participated in the study. The completeness of the responses was considered and they were then analyzed using the SPSS computer program. Frequency and percentages were used to obtain the results for each item. The responses from each group of participants, namely, science teachers, students, and science educators were compared to find corresponding elements among the responses. The highest percentages among the responses are presented in this paper.

Results

The state of teaching and learning science according to basic science curriculum reform in Thailand included the following topics: (1) background information, (2) general information on teaching and learning, workloads, and associated activities, (3) views about science teaching and learning and (4) factors that limit the ways science is taught in science classes.

1. Background Information

The majority of teachers were female, 40-49 years old, had 26-30 years of teaching experience, had university bachelor degrees in science/mathematics education, were fulltime teachers, and were teaching a subject after undergoing professional preparation or training. Most students were studying in junior high schools, had computers and calculators at home, and their fathers and mothers had attended a university. Most science educators had degrees in education, taught physics, and had more than 26 years of teaching experience. The details are shown in Table 1.

Table 1. Background information of science teachers, students and science educators

Science teachers **N= 166**	**Students** **N= 1764**	**Science educators** **N= 128**
64.5% were female	64.3% were female	50.8% were female
50.6% were 40-49 years old	39.7% were 10^{th} grade students	42.2% were 50-59 years old
21.0% had 26-30 years of	71.6% sometimes spoke	25.8% had 26-30 years of
teaching experiences 69.9% had university bachelor degree in science-math education	English at home 57.2% had computer and 89.9% had calculator at home	teaching experience - 49.2% had bachelor degree in education - 27.3% were in the Physics discipline

Table 1. (cont.)

Science teachers N= 166	Students N= 1764	Science educators N= 128
		- 84.4% had professional qualification in education
91.1% were full-time teachers	- 42.0% spent 1-2 hrs working at a paid job before or after school - 41.6% spent no time on taking extra lessons in science, or taking private tuition in science (40.0%)* or in other subjects (62.7%) or participating in science club (66.2%)	97.7% were full-time lecturers
91.6% were teaching a subject after undergoing professional preparation or training	40.1% expect to go to university	
73.5% were sufficiently prepared to teach their present class subjects	Father (21.6%) and Mother (20.4%) went to the university	

* Number in parenthesis shows the highest percentage among the responses

2. General Information on Teaching and Learning, Workloads, and Associated Activities

2.1 Science teachers' and science educators' workloads and associated activities

130 (78.3%) of the science teachers taught science for 18-20 hours during a typical school week. 87 (52.4%) of the science teachers had meetings with other science teachers to discuss and plan curricula or teaching approaches once or twice a year.

66 (51.6%) of the science educators had been actively engaged in research for less than 5 years and 96 (75.0%) had had meetings with other science educators to discuss and plan curricula, teaching approaches, and research once or twice a year.

2.2 Students' associated activities

On a normal school day, 765 (43.6%) of the students spent 1-2 hours playing or talking with friends, 787 (44.9%) spent 1-2 hours reading a book for enjoyment, 922 (52.6%) spent 1-2 hours studying or doing science homework after school, 922 (52.6%) spent 1-2 hours studying or doing homework for school subjects other than science. 702 (40.0%) of them also spent less than one hour playing computer games, 737 (42.0%) spent less than one hour doing jobs at home, and 855 (48.7%) spent less than one hour playing sports.

1025 (58.4%) of fathers and 1055 (60.1%) of mothers thought that it was important for students to do well in Thai language while 848 (48.1%) of their friends and 975 (55.6%) of the students themselves thought that it was important to have fun. 1253 (71.4%) of the students thought that they did well in science at school and thought that to do well in science they needed to pay attention in class, understand scientific concepts, principles, and strategies, do many test exercises, and remember formulae and procedures. 1002 (68.5%) of the students liked science and 62.3% used computers in science classes.

2.3 Science teachers' and science educators' activities outside the scheduled teaching hours

Outside the scheduled teaching hours, most science teachers and science educators spent more than four hours each planning lessons, and reading and grading student work. They spent 1-2 hours each, meeting with students outside of classroom time, preparing or grading student tests or exams, and participating in administrative tasks including attending staff meetings, reading professional materials, and engaging in development activities. 95 (57.2%) of the science teachers spent less than 1 hour meeting with parents and 56 (33.7%) spent 1-2 hours keeping students๓ records up to date. 39 (30.5%) of the science educators spent 1-2 hours on research and 50 (39.1%) spent less than 1 hour keeping students๓ records up to date.

2.4 Familiarity with documents

106 (63.9%) of the science teachers were *very familiar* with the Science Standard and Benchmark and 93 (56.0%) were *very familiar* with the IPST Basic Science Curriculum, while the science educators were *familiar* with them. Both science teachers and science educators were *fairly familiar* with the National Education Act B.E. 2542 (1999), the MOE Basic Curriculum B.E. 2544, and the Teacher Manual in Basic Science Curriculum. 5 (3.1%) of the science teachers and 28 (21.7%) of the science educators were not familiar with the National Science Curriculum documents. The details are shown in Table 2.

2.5 Influence on school science curriculum

Table 2. Science teachers' and science educators' level of familiarity with the documents

Documents	**Level of familiarity**	
	Science teachers	**Science educators**
a) Science Standard and Benchmark	Very familiar (63.9%)*	Fairly familiar (44.5%)
b) IPST Basic Science Curriculum	Very familiar (56.0%)	Fairly familiar (39.1%)
c) National Education Act B.E. 2542 (1999)	Fairly familiar (65.7%)	Fairly familiar (49.2%)
d) The MOE Basic Curriculum B.E 2544	Fairly familiar (54.2%)	Fairly familiar (43.8%)
e) Teacher Manual in Basic Science Curriculum	Fairly familiar (51.2%)	Fairly familiar (38.3%)

* Number in parenthesis shows the highest percentage among the responses.

Regarding influence on the science curriculum, 87 (52.4%) of the science teachers had *some* influence on school examinations, 77 (46.4%) had *some* influence on what supplies are purchased, 74 (44.6%) had *some* influence on specific textbooks to be used, 74 (44.6%) had *some* influence on the amount of money to be spent on equipment and supplies, and 73 (44.0%) had *some* influence on the subject matter to be taught, while science educators had *no* influence on these matters. Both science teachers and science educators had *no* influence on National Science Examinations ("O"/ "A" levels).

Besides these influences on the science curriculum, 53 (41.1%) of the science educators had *no* influence on examinations in their courses, 56 (43.2%) had no influence on how science subjects should be taught, 65 (50.8%) had no influence on how science education subjects should be taught, 94 (73.4%) had no influence on the primary school science curriculum, 57 (44.5%) had no influence on the secondary or junior high school science curriculum, and 112 (87.5%) had no influence on MOE policies.

3. View about Science Teaching / Learning

3.1 Planning science lessons

3.1.1 Documents to be relied upon when planning science lessons

When planning science lessons, 92 (55.4%) of the science teachers *always* relied on their own previously prepared lessons, 82 (49.4%) always relied on other textbooks or resource books, and 80 (48.2%) always relied on teacher guides or teacher editions of textbooks. 81 (48.3%)) of the teachers *sometimes* relied on national examinations or standardized tests, 77 (46.4%) *sometimes* relied on student textbooks, workbooks, and practical books, 67 (40.4%) *sometimes* relied on a written plan compiled by teachers in the school, and 67 (40.4%) *sometimes* relied on other teachers or science specialists.

3.1.2 The main source of written information to be used in the planning of science lessons

In planning science lessons, 85 (51.2%) of the science teachers used the Basic Science Curriculum to decide which topics to teach, 80 (48.2%) used the IPST Learning Standard to decide how to present a topic, 80 (48.2%) used textbooks, exercises, laboratory manuals, and teacher manuals to select problems and exercises for use in class and for homework. 64 (38.6%) used textbooks, exercises, laboratory manuals, and teacher manuals to select science hands-on activities and experiments. These corresponded to the science educators' perceptions regarding using these sources of written information when planning science lessons. However, 47 (28.3%) of the science teachers used the IPST Learning Standard and textbooks, exercises, laboratory manuals, and teacher manuals to select problems and applications for assessment and evaluation. 38 (29.7%) of the science educators thought that school science exams should be the main source of problems and applications for assessment and evaluation.

3.1.3 Conducting different types of classes

To conduct different types of classes, the majority of the science teachers used revision almost every day, used laboratory activities, and quantitative problem solving once or twice a week, and used enrichment activities once or twice a month. These corresponded to the science educators' perceptions regarding the teaching of science. However, the majority of the science teachers conducted remedial activity once or twice a month while the majority of the science educators thought that remedial activity should be conducted once or twice a week.

When students were asked about what was going on in science classrooms and the frequency of the activities, the majority of the students said that what *almost always* happened in science classrooms was that the teachers showed students how to do science. The majority of the students copied notes from the board and had a quiz or a test. The majority of the students said that what happened *pretty often* was students used things from every day life to solve science problems, worked from worksheets or textbooks on their own, and the majority of the students said that they worked on science projects *once in a while.* The details are shown in Table 3.

Table 3. Science teachers', science educators', and students' level of frequency in conducting different types of classes

<table>
<tr><th rowspan="2">Types of classes</th><th colspan="2">Level of frequency</th><th rowspan="2">Students</th></tr>
<tr><th>Science teachers</th><th>Science educators</th></tr>
<tr><td>a) Revision</td><td>Almost every day (39.8%)*</td><td>Almost every day (46.9%)</td><td rowspan="6">The following almost always happened in science classrooms:
- Teacher shows how to do science problems (45.7%)
- Students copy notes from the board (47.4%)
- Students have a quiz or test (46.2%)
The following pretty often happened in science classrooms:
- Students use things from everyday life in solving science problems (45.2%)
- Students work from worksheets or textbooks on their own (43.6%)
The following happened once in a while in science classrooms:
- Students work on science projects (42.7%)</td></tr>
<tr><td>b) Laboratory</td><td>Once or twice a week (52.4%)</td><td>Once or twice a week (60.9%)</td></tr>
<tr><td>c) Quantitative problem solving</td><td>Once or twice a week (43.4%)</td><td>Once or twice a week (53.9%)</td></tr>
<tr><td>d) Enrichment</td><td>Once or twice a month (42.8%)</td><td>Once or twice a month (40.6%)</td></tr>
<tr><td>e) Remedial</td><td>Once or twice a month (34.3%)</td><td>Once or twice a week (39.8%)</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

* Number in parenthesis shows the highest percentage among the responses.

3.1.4 Activities students are asked to do

In science lessons, most science teachers asked students to do many activities. The activities that science teachers and science educators agreed to ask students to do in *some lessons* were practicing computational skills, and working on problems for which there was no immediately obvious method of solution. The ones that science teachers asked students to do in *most lessons* (but science educators thought that teachers should ask students to do in every lesson) were giving every day real-life examples or applications related to a concept or topic, explaining the reasoning behind an idea, writing explanations about what was observed and why it happened, and making connections with previously learned concepts. The ones that science teachers asked students to do in *some lessons* (but science educators thought that teachers should ask students to do in most lessons) were representing and analyzing relationships using tables, charts, or graphs, and sketching or drawing diagrams to indicate better understanding. The disagreements were based on the different levels of frequency in asking students to do the activities. The details are shown in the Table 4

Table 4. Science teachers' and science educators' level of frequency in asking students to perform activities

Activities	Level of frequency	
	Science teachers	Science educators
a) Give everyday life examples or applications related to a concept or topic	Most lessons (47.6%)*	Every lesson (61.7%)
b) Explain the reasoning behind an idea	Most lessons (47.0%)	Every lesson (50.8%)
c) Write explanations about what was observed and why it happened	Most lessons (43.4%)	Every lesson (46.9%)
d) Make connections with previously learnt concepts	Most lessons (41.6%)	Every lesson (58.6%)
e) Practice computational skills	Some lessons (67.5%)	Some lessons (46.9%)
f) Represent and analyze relationships using tables, charts, or graphs	Some lessons (60.2%)	Most lessons (41.4%)
g) Work on problems for which there is no immediately obvious method of solution	Some lessons (59.6%)	Some lessons (47.7%)
h) Sketch or draw diagrams to indicate better understanding	Some lessons (47.6%)	Most lessons (45.3%)

* Number in parenthesis shows the highest percentages among the responses.

3.1.5 Science teachers' behavior when a student gives an incorrect response

In science lessons, when a student gave an incorrect response during a class discussion, most science teachers and science educators agreed to correct the studentഀs error in front of the class in *some* lessons. The behavior that science teachers followed in *most* lessons or *some* lessons, but science educators thought that teachers should follow in *every* lesson or *some* lessons, was asking the student another question to help him/her to arrive at the correct response, calling on other students to give their responses and then discussing what was correct, rephrasing the initial question to help him/her with the correct response, asking the student to explain why he/she gave the response and calling on another student who was likely to give the correct response. The answers of science teachers and science educators varied in the frequency of the application of these behaviors. The details are shown in the Table 5

Table 5. Science teachers' and science educators' level of frequency in their behavior

Behavior	Level of frequency	
	Science teachers	Science educators
a) Ask the student another question to help him/her get the correct response	Most lessons (56.6%)*	Every lesson (43.8%)
b) Call on other students to get their responses and then discuss what is correct	Most lessons (49.4%)	Some lessons (43.0%)
c) Rephrase the initial question to help him/her get the correct response	Most lessons (48.8%)	Every lesson (39.8%)
d) Ask the student to explain why he/she gave the response	Most lessons (48.2%)	Every lesson (39.8%)
e) Correct the student's error in front of the class	Some lessons (57.2%)	Some lessons (46.9%)
f) Call on another student who's likely to give the correct response	Some lessons (44.0%)	Every lesson (52.3%)

* Number in parenthesis shows the highest percentages among the responses.

3.1.6 Student group work

When asking science teachers about how often the students worked in groups or worked individually, 133 (80.1%) of the science teachers replied that students worked individually with assistance from the teacher in *some* lessons, 116 (69.9%) worked individually without assistance from the teacher in *some* lessons, 104 (62.7%) worked in pairs or small groups without assistance from the teacher in *some* lessons, 89 (53.6%) worked in pairs or small groups with assistance from the teacher in *some* lessons, and 76 (45.8%) worked together as a class with students responding to one another in *some* lessons. These results corresponded to science educators๓ perceptions regarding students working in groups or individually. But 69 (41.6%) of the science teachers let students work together as a class with the teacher teaching the whole class in *most* lessons while 68 (53.1%) science educators thought that the students should work together as a class with the teacher teaching the whole class in *some* lessons. The details are shown in Table 6.

Table 6. Frequency level of students' working in groups according to science teachers' and science educators' opinion

Group work	Frequency level	
	Science teachers	Science educators
a) Work together as a class with the teacher teaching the whole class.	Most lessons (41.6%)*	Some lessons (53.1%)
b) Work individually with assistance from the teacher	Some lessons (80.1%)	Some lessons (82.8%)
c) Work individually without assistance from the teacher.	Some lessons (69.9%)	Some lessons (67.2%)
d) Work in pairs or small groups without assistance from the teacher	Some lessons (62.7%)	Some lessons (66.4%)
e) Work in pairs or small groups with assistance from the teacher	Some lessons (53.6%)	Some lessons (58.6%)
f) Work together as a class with students responding to one another	Some lessons (45.8%)	Some lessons (42.2%)

* Number in parenthesis shows the highest percentage among the responses.

3.1.7 Student homework

129 (77.7%) of the science teachers assigned students science homework and 107 (65.4%) assigned homework once or twice a week. When science teachers assigned science homework, 82 (49.4%) assigned 15-30 minutes of homework. 126 (98.4%) of science educators thought that science teachers should assign students science homework and 90 (70.3%) thought that science teachers should assign homework once or twice a week. 64 (50.0%) of the science educators thought that they should assign 31-60 minutes of homework.

3.1.8 Kinds of tasks that science teachers assigned for science homework

When science homework was assigned, science teachers, science educators, and students had the same corresponding ideas. Science teachers assigned the following kinds of tasks *sometimes*:

preparing oral reports either individually or as a small group, writing definitions or other short writing assignments, demonstrations or other hands-on activities, working individually on long term projects or experiments, and working as a small group on long term projects or experiments. Other kinds of tasks were assigned at different levels of frequency by science teachers, science educators, and students. These included working on worksheets or in workbooks, explaining specific observations or phenomena, sketching or drawing diagrams, finding one or more uses of the content covered, small investigations, gathering data, teacher-compiled or teacher-designed exercises or problems, problem/question sets in textbooks, and reading in textbooks or supplementary materials. It was noticed that science teachers rarely or never assigned students to keep a journal, do internet-based or computer-based virtual experiments, do internet-based or computer-based quizzes, or do internet-based or computer-based exercises or problems.

3.2 Instructional Materials

3.2.1 Textbooks

It was found that 136 (81.9%) of the science teachers used a textbook to teach science and 51-75 % of weekly science teaching time was based on the textbook. When asked to select five characteristics that they considered to be the most important for a good science textbook, science teachers and science educators agreed that the following characteristics were the most important: 1) facilitating students to learn by themselves and to inquire actively, 2) having a well-organized knowledge structure, 3) providing students with comprehensive and rich content, and 4) remaining in accordance with students' cognitive development. The fifth characteristic of a good science textbook for most science teachers was having sufficient hands-on experiments for students, and presenting ways to explore science and methods of scientific research.

The students named only one characteristic of a good science textbook that corresponded with both science teachers and science educators: providing students with comprehensive and rich content. The other four characteristics of a good science textbook were 1) writing according to scientific logic, 2) reflecting the latest developments in science and technology, 3) using various representations including graphics, pictures, and charts, and 4) being vivid and interesting.

3.2.2 Educational resources

In addition to using a textbook, most science educators agreed with 152 (91.6%) of science teachers that they used notes and worksheets designed by teachers. 133 (80.1%) used compilations of notes and worksheets from different sources, 117 (70.5%) used teacher's guides written by the textbook's publisher, 114 (68.7%) used compilations of problem sets from different sources, 108 (65.1%) used compilations of experiments from different sources, 100 (60.2%) used resources from internet websites, 99 (59.6%) used compilations of hands-on activities from different sources, 81 (48.8%) used assessment books from different publishers, 71 (42.8%) used television programs, 70 (42.2%) used compilations of demonstrations from different sources, and 39 (23.5%) used a ten-year examination series.

Students also agreed that they used these resources in addition to a science textbook, but the percentage of students using these resources varied from the percentage of science teachers who used these resources. The details are shown in Table 7.

Table 7. Percentages of science teachers, science educators and students using resources

Resources	**Percentages**		
	Science teachers	**Science educators**	**Students**
a) Notes and worksheets designed by teacher	91.6%	Agree (53.1%)*	-
b) Compilation of notes and worksheets from different sources (by teachers)	80.1%	Agree (63.3%)	82.5%
c) Teacher guide by textbook's publisher	70.5%	Agree (55.5%)	-
d) Compilation of problem sets from different sources (by teachers)	68.7%	Agree (65.6%)	53.2%
e) Compilation of experiments from different sources (by teachers)	65.15	Agree (58.6%)	48.4%
f) Resources from internet websites	60.2%	Strongly agree (56.3%)	43.0%
g) Compilation of hands-on activities from different sources (by teachers)	59.6%	Agree (51.6%)	44.7%
h) Assessment books from different publishers	48.8%	Agree (56.3%)	21.3%
i) Television programs	42.8%	-	45.4%
j) Compilation of demonstrations from different sources (by teachers)	42.2%	Agree (61.7%)	30.2%
k) Ten-year examination series	23.5%	Agree (54.7%)	14.8%

* Number in parenthesis shows the highest percentage among the responses.

3.2.3 Computers

115 (69.3%) of the science teachers said that students had access to computers 0-25% of the time during science lessons, and 48 (37.5%) of science educators thought that students should have access to computers 76-100% of the time during science lessons. 551 (34.1%) of the students said that they used computers *once in a while* and 455 (25.9%) of the students never used computers.

When asked about students using computers in the science class, 73 (44.0%) of the science teachers let the students use computers to write reports, and 70 (42.2%) of the science teachers let the students use computers to surf the internet for information *once or twice a month*. 121 (72.9%) of science teachers *never* let students use computers for solving complex problems, 110 (66.3%) *never* let students use computers for conducting experiments using data-loggers, 109 (65.7%) *never* let students use computers for performing routine computations, 106 (63.9%) *never* let students use computers for analyzing data to find patterns and relationships, 106 (63.9%) *never* let students use computers for independent learning with teacher-designed materials on the computer, 98 (59.0%) *never* let students use computers for taking quizzes, tests, or examinations, 90 (54.2%) *never* let students use computers for plotting graphs, 89 (53.6%) *never* let students use computers for preparing PowerPoint presentations, and 73 (44.0%) *never* let students use computers for independent learning with CD-ROMs and other computer software. This did not correspond to the science educators๓ perceptions because most science educators thought that students should use computers in these activities at least *once or twice a month.*

3.3 Assessment

3.3.1 Weight given to the types of assessment

In assessing the work of the students in science classes, science teachers, science educators, and students all believed that the following types of assessment were given to students *quite a lot*: 1) student performance on projects or practical / laboratory exercises, 2) short answer or essay tests produced by teachers that require students to describe or explain their reasoning, 3) how well students do on homework assignments, 4) responses of students in class, and 5) student observations. Other types of assessment such as standardized tests produced outside of the school and multiple choices, true-false, and matching tests produced by teachers, were given to students at different frequencies by science teachers, science educators, and students. The details are shown in Table 8.

Table 8. Level of weight given to the types of assessment by science teachers, science educators, and students

Type of assessment	**Level of weight**		
	Science teachers	**Science educators**	**Students**
a) How well students do on projects or practical/laboratory exercises	Quite a lot (66.9%)*	Quite a lot (53.9%)	Quite a lot (56.7%)
b) Teacher-made short answer or essay tests that require students to describe or explain their reasoning	Quite a lot (66.3%)	Quite a lot (58.6%)	Quite a lot (59.4%)
c) How well students do on homework assignments	Quite a lot (63.3%)	Quite a lot (67.2%)	Quite a lot (53.1%)
d) Responses of students in class	Quite a lot (58.4%)	Quite a lot (51.6%)	Quite a lot (53.2%)
e) Observations of students	Quite a lot (57.2%)	Quite a lot (48.4%)	Quite a lot (56.7%)
f) Standardized tests produced outside the school	A little (51.2%)	Quite a lot (49.2%)	Quite a lot (64.0%)
g) Teacher made multiple choice, true-false and matching tests	A little (49.4%)	A little (61.7%)	Quite a lot (50.6%)

* Number in parenthesis shows the highest percentage among the responses.

3.3.2 Using the assessment information from students

When asked about how often the assessment information from students was used, science teachers, science educators, and students believed that the assessment information was used *quite a lot* to 1) provide students’ grades or marks, 2) plan for future lessons, 3) provide feedback to students and 4) diagnose students’ learning problems. The use of assessment information from students to diagnose students’ alternative conceptions, to report to parents, and to assign students to different programs or tracks was believed to be used at different levels of frequency by science teachers, science educators, and students. The details are shown in Table 9.

Table 9. Level of frequency in using assessment information by science teachers, science educators, and students

Using assessment information	Level of frequency		
	Science teachers	Science educators	Students
a) Provide students๓ grades or marks	Quite a lot (66.3%)*	Quite a lot (54.7%)	Quite a lot (47.0%)
b) Plan for future lessons	Quite a lot (62.0%)	Quite a lot (62.5%)	Quite a lot (54.7%)
c) Provide feedback to students	Quite a lot (61.4%)	Quite a lot (58.6%)	Quite a lot (39.7%)
d) Diagnose students๓ learning problems	Quite a lot (57.8%)	Quite a lot (59.4%)	Quite a lot (42.0%)
e) Diagnose students๓ alternative conceptions	Quite a lot (47.0%)	Quite a lot (55.5%)	A little (45.7%)
f) Report to parents	A little (44.0%)	Quite a lot (53.1%)	A little (47.7%)
g) Assign students to different programs or tracks	A little (42.2%)	Quite a lot (64.8%)	A little (40.4%)

* Number in parenthesis shows the highest percentage among the responses.

3.3.3 Kinds of tests used in science learning

Most science teachers, science educators, and students agreed that the following kinds of tests could evaluate how well students had learned science: 1) written assignment, 2) oral test, 3) practical test, 4) paper-pencil (written) test, 5) hands-on skill test, and 6) project work. The details are shown in Table 10.

Table 10. Level of agreement in using kinds of tests in science learning by science teachers, science educators, and students

Kind of test	Level of agreement		
	Science teachers	Science educators	Students
a) Written assignment	Agree (70.5%)*	Agree (75.0%)	Agree (62.2%)
b) Oral test	Agree (69.9%)	Agree (68.8%)	Agree (56.7%)
c) Practical test	Agree (65.7%)	Agree (56.3%)	Agree (54.2%)
d) Paper-pencil (written) test	Agree (62.7%)	Agree (56.3%)	Agree (62.4%)
e) Hands-on skill test	Agree (60.8%) (53.1%)	Strongly agree	Agree (65.7%)
f) Project work	Agree (56.6%)	Agree (53.1%)	Agree (56.3%)

* Number in parenthesis shows the highest percentage among the responses.

4. Factors that limit how science is taught in science classes

Most science teachers and science educators agreed that the following factors limited how science is taught in science classes *quite a lot*: 1) students with special needs, 2) uninterested students, 3) shortage of other instructional equipment for students๓ use, 4) shortage of equipment for use in demonstrations and other exercises, 5) low morale among students, 6) high student / teacher ratio, 7) low morale among fellow teachers / administrators. They also agreed that the following factors limited how science was taught in science classes *a little*: 1) shortage of computer hardware, 2) shortage of computer software,

3) shortage of calculators, 4) students who come from a wide range of backgrounds, 5) inadequate physical facilities, 6) students with different academic abilities, and 7) disruptive students. Besides these factors, they agreed that parents൲ interest in their children൲s learning and progress did not limit how science is taught in science classes at all.

Discussion

The results of the study strongly indicate that science teachers still have plenty of work to do. Besides, 18-20 hour teaching loads, some science teachers spend a number of hours per week doing the following activities outside of scheduled teaching hours: planning lessons, reading and grading student work, meeting with students outside of classroom time, preparing or grading student tests or exams, doing administrative tasks including staff meetings, professional reading and development activities, meeting with parents, and keeping students൲ records up to date. This result corresponds to the study of the Office of the Private Administration Commission (2002) and the Institute for the Promotion of Teaching and Learning Science and Technology (2002a, 2002b).

Since 1999, Thailand has used the first National Educational Act to serve as the fundamental law for the administration and provision of education and training. This was followed by the 2001 Curriculum for Basic Education and the IPST Science Standard and Benchmark. The results from this study show that as time has passed, some science teachers have become familiar with the Science Standard and Benchmark, IPST Basic Science Curriculum, National Education Act B.E. 2542 (1999), the MOE Basic Curriculum B.E. 2544, and the Teacher Manual in Basic Science Curriculum. However some teachers are unfamiliar with the National Science Curriculum documents which may relate to a lack of success in implementing learning reform in the classroom.

However, some science teachers use standards for curriculum content to ensure that what is taught is consistent with the goals of reform. These results confirm that some science teachers teach according to the IPST Basic Science Curriculum (2001) that encourages the students to experience knowledge and processes. They undertake activities that help to develop reasoning, critical and creative thinking, analytical ability, skills in research, creating knowledge through investigation, systematic problem solving and decision making based on diverse data and verifiable evidence, and skills in utilizing technology for data acquisition and management.

Some science teachers also use different types of materials corresponding to the IPST Basic Science Curriculum (2001). These learning materials stimulate valuable learning, attract attention, are thought provoking, are easily and quickly understood, motivate skillful searches for knowledge, and continuously broaden the scope of in-depth learning. Learning resources that science teachers used in this study were teachers, friends, parents, local resources, publishers, textbooks, reference materials, external reading, newspapers, magazines, visual aids, manipulative objects, computer aided instruction (CAI), software, the internet, and calculators.

Some science teachers in this study followed Section 26 of the National Education Act (Office of the National Education Commission, 1999) that states that educational institutions shall access learners൲ performances through observation of their development, personal conduct, learning behavior, and participation in activities. The results correspond to the IPST Basic Science Curriculum (2001) that states that various methods shall be used to determine results from learning activities. Measurement and evaluation processes cover personal conduct, behavior, learning procedures, activities, participation, project work or portfolios. Important users of classroom measurement and evaluation files are learners, teachers, and parents.

The results of this study have some limitations that correspond with Moeynorata (1997), Office of the National Education Commission (1999), and the Institution of the Development of Education, Religion, and Culture, in Educational Area 6 (1998). These studies found that the shortage of budget resources and instructional materials, and students๓ interest in and intentions towards learning are the causes of problems in teaching science in science classes. The results of this study also correspond with the study of the Office of the Private Administration Commission, (2004), and the Institute for the Promotion of Teaching and Learning Science and Technology (2002a, 2002b). They found that inadequate and out of date books and materials, and inadequate numbers of computers caused problems with teaching and learning.

Science teachers in this study have taught following the Basic Science Curriculum Reform to some degree. It has to be determined why teachers don๓t fully follow the curriculum. Some teachers should attend professional development programs to make them feel comfortable following the National Education Act.

Conclusion

It can be concluded that science teachers have implemented the new curriculum using a student-centered approach following the learning process reform efforts in accordance with the 2001 Basic Science Curriculum and 1999 National Education Act to some degree. This has impacted students๓ learning to some extent. Teachers๓ preparation for teaching, their familiarity with the science curriculum documents, teaching practices, assessing students๓ learning outcomes in science classrooms, instructional materials and learning resources used, working with students, and contact with parents show that teaching practices are increasingly valuing students' background knowledge, abilities, interests, and aptitude.

All teachers who participated in the study are in schools under the supervision of the IPST leader school project. These teachers work directly or more closely with IPST science educators than teachers in other schools. However, half of them still need more improvement in some areas. Continuous professional development in science is still needed to find effective ways to help teachers to improve their teaching practices in science classrooms. More concern with specific information about teaching and learning through direct observation in each science classroom should be considered in order to solve existing problems. Additionally, the study should include elementary schools and use a qualitative approach for the in-depth study to understand other factors concerning the state of teaching and learning science.

References

Boonklurb, N. 2000. Current Trends and Main Concerns as Regards Science Curriculum: Thailand.

Available: http://www.ibe.unesco.org/curriculum/china/pdf/llthailand.pdf. March 29, 2006, Thailand.

Institute for the Promotion of teaching Science and Technology, Ministry of Education. 2001. **Basic Education Curriculum B.E. 2544 (A.D. 2001).** Bangkok: The Express Transportation Organization of Thailand (ETO).

___________. 2002a. **Content and Standards of Science Learning Group**. Bangkok: The Express Transportation Organization of Thailand (ETO).

___________. 2002b. **Development of Teaching and Learning Science and Mathematics at Lower Secondary Schools.** Bangkok: Institute for the Promotion of Teaching Science and Technology, Ministry of Education.

Moeynorata, J. 1997. **Science Instructional Organization in Schools under the Project for Extension of Education Opportunity at the Lower Secondary Level of the Bangkok Metropolis Administration**. Master Thesis, Kasetsart University.

Office of Development of Education, Religion, and Culture, Education Area 6. 1998. **The Study of Teaching and Learning Science by Student-centered Approach at Lower Secondary Level in Public Schools under the General Education Department**. Bangkok: Office of Development of Education, Religion, and Culture, Education Area 6.

Office of the Education Council. 2004. **Education in Thailand 2004**. Bangkok: Amarin Printing and publishing.

Office of the National Education Commission (ONEC). 1999. **Learning Reform: A Must for a Nation. Available: http://www.edthai.com/reform/dec03a.htm**. March 29, 2006.

___________. 2000. **National Education Act B.E. 2542 (1999)**. Bangkok: Prig Wan Graphic.

___________. 2002. **Education in Thailand 2001/2002**. Bangkok: Kurusapa Lardprao Press.

___________. 2003. **Education in Thailand 2002/2003**. Bangkok: Amarin Printing and Publishing.

Office of the Private Education Commission. 2004. **Science Curriculum-The Private School Level 1-4 (G. 1-12) In Basic Education Curriculum B.E. 2544 (A.D. 2001).** Bangkok: Office of the Private Education Commission.

Office of the Private Education Commission. 2002. **Teaching and Learning Situation of the Lower Secondary Level in Private Section.** Bangkok: Policy and Planning Department, Office of the Private Education Commission.

Sub-Committee on Learning Reform of the National Education Commission (NEC). 2000. **Learning Reform: A Learner-Centered Approach**. Bangkok: Office of the National Education Commission.