

Development of the program for enhancing integrated science process skills,
ability in analyzing, and scientific mind of Mathayomsuksa 4 students
through the integration of authentic assessment
การพัฒนาโปรแกรมสร้างเสริมทักษะกระบวนการทางวิทยาศาสตร์ชั้นบูรณาการความสามารถ
ในการวิเคราะห์ และจิตวิทยาศาสตร์ ของนักเรียนชั้นมัธยมศึกษาปีที่ 4
โดยบูรณาการการประเมินตามสภาพจริง

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Abstract

The purposes of this study were to develop the program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment, and to trial the program. The instruments used for data collection consisted of integrated science process skills test, integrated science process skills performance assessment, ability in analyzing test, scientific mind test, and satisfaction questionnaires. The data was analyzed by mean and standard deviation while the hypothesis was examined by t-test dependent samples. The results showed that the program which was developed tended to focus on developing of students' integrated science process skills, ability in analyzing, and scientific mind through experimental activities including chromatography, properties of carbohydrates, acid – base on a daily, natural indicator, and electrical conductivity. The process of learning in each activities integrated authentic assessment into 5Es instruction model consisting of six stages which were self-assessment and goal setting, plan do and check, analysis and synthesis, present and discussion, summarize and evaluate and creating product. The result of trial found that students' integrated science process skills and ability in analyzing and scientific mind were higher than before participating in the program at .05 significant levels and their students' satisfaction to participate in the program was in high level as a whole.

Keywords : Program/Integrated science process skills/Ability in analyzing/Scientific mind/
Authentic assessment

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บทคัดย่อ

การวิจัยครั้งนี้มีจุดมุ่งหมายเพื่อพัฒนาโปรแกรมสร้างเสริมทักษะกระบวนการทางวิทยาศาสตร์ขั้นบูรณาการ ความสามารถในการวิเคราะห์ และจิตวิทยาศาสตร์ ของนักเรียนในระดับชั้นมัธยมศึกษาปีที่ 4 โดยบูรณาการ การประเมินตามสภาพจริง และทดลองโปรแกรมที่ผู้ศึกษาพัฒนาขึ้น เครื่องมือที่ใช้ในการเก็บรวบรวมข้อมูลประกอบด้วย แบบทดสอบวัดทักษะกระบวนการทางวิทยาศาสตร์ขั้นบูรณาการ แบบประเมินทักษะกระบวนการทางวิทยาศาสตร์ ขั้นบูรณาการ แบบวัดความสามารถในการวิเคราะห์ แบบวัดจิตวิทยาศาสตร์ และแบบสอบถามความพึงพอใจของนักเรียนที่มีต่อการเข้าร่วมโปรแกรม สถิติที่ใช้ในการวิเคราะห์ข้อมูลได้แก่ ค่าเฉลี่ย ส่วนเบี่ยงเบนมาตรฐาน และทดสอบสมมติฐานด้วยสถิติทดสอบที แบบกลุ่มสัมพันธ์ ผลการวิจัย พบว่า โปรแกรมที่พัฒนาขึ้น เป็นโปรแกรมที่มุ่งเน้นให้นักเรียนได้พัฒนาทักษะกระบวนการทางวิทยาศาสตร์ขั้นบูรณาการ ความสามารถในการวิเคราะห์ และจิตวิทยาศาสตร์ ผ่านกิจกรรมการทดลองเป็นกิจกรรมหลัก ได้แก่ โครมาโทรกราฟี สมบัติบางประการของคาร์โบไฮเดรต กรดเบสในชีวิตประจำวัน อินดิเคเตอร์จากธรรมชาติ และการนำไฟฟ้า ขั้นตอน ของการจัดการเรียนรู้ในแต่ละกิจกรรมจะบูรณาการการประเมินตามสภาพจริงเข้ากับรูปแบบการสอนแบบวัฏจักรเรียนรู้ 5 ขั้น เกิดเป็นขั้นตอนในการจัดการเรียนรู้ 6 ขั้น ประกอบด้วย ขั้นประเมินตนเองและกำหนดเป้าหมายการเรียนรู้ ขั้นวางแผน ปฏิบัติตามแผนและตรวจสอบ ขั้นวิเคราะห์ สังเคราะห์และต่อยอดประสบการณ์ ขั้นนำเสนอ อภิปราย ชักถาม ขั้นสรุปและประเมินตนเอง และขั้นสร้างชิ้นงาน ผลการทดลองโปรแกรม พบว่า นักเรียนมีทักษะกระบวนการทางวิทยาศาสตร์ขั้นบูรณาการ ความสามารถในการวิเคราะห์ และจิตวิทยาศาสตร์ หลังการเข้าร่วมโปรแกรมสูงกว่าก่อนการเข้าร่วมโปรแกรม อย่างมีนัยสำคัญทางสถิติที่ระดับ .05 และมีความพึงพอใจต่อการเข้าร่วมโปรแกรมโดยรวมอยู่ในระดับมาก

คำสำคัญ : โปรแกรม/ทักษะกระบวนการทางวิทยาศาสตร์ขั้นบูรณาการ/ความสามารถในการวิเคราะห์/จิตวิทยาศาสตร์/การประเมินตามสภาพจริง

Introduction

Science is necessary for development of human and society. Learning and knowledge creation or innovation need to rely on the scientific basis because science was an important tool that allowed human to develop ways of thinking in terms of rationality, creativity, analytical thinking, criticism, the skills and ability to gain knowledge and to solve problems systematically. (The Ministry of Education. 2008 : 1) Therefore, everyone needs to be developed their scientific skills as we can see that there has been teaching of science in schools. The teaching of science will be successful if the learners are taught to know both the knowledge that related to scientific and a process of knowledge acquirement. (Chundapradit. 1994 : 19)

Science process skills are behaviors that scientists used for seeking knowledge under the scientific methods, and are basis for development of higher-ordered thinking skills such as analytical thinking, synthetic thinking, critical thinking, decision making, and problem solving skills. (Karsli. 2009 : 2) Science process skills are relevant to cognitive skills because

science process skills are intellectual skills that are resulted from the systematical ideas and practices for a long time. (Chundapradit. 1994 : 36) Science process skills relate to cognitive skill on the part of ability in analyzing, because ability in analyzing is the ability to classify elements of situations or events in terms of contents, structures and principles. (Bloom and others. 1956 : 144) The ability in analyzing relates to science process skills in many ways, such as classification, forecasting, formulating hypotheses, interpreting data, concluding, and etc. The learners must have these skills before projecting science process skills. Meanwhile, when learners have science process skills, it will affect in analyzing things better so they can seek the knowledge more effectively. Apart from science process skills and ability in analyzing, another key element of the process of seeking scientific knowledge is scientific mind or scientific attitudes. (Roadrangka and Nuankeaw. 1999 : 6) This was said because scientific mind is consciousness, behavior expression and the features or the habits of humans in science, for example curiosity, responsibility and patience, rationality, orderliness and diligence, honesty and openness, the ability to work with others , and etc. (The Institute for the Promotion of Teaching Science and Technology. 2012 : 146) This can result in a process of seeking knowledge and truth based on accuracy and reliability. So science process skills, ability in analyzing and scientific mind, are important variables that should be developed in learners. So, it will be useful for self-development of the learners for seeking knowledge and problem solving systematically.

The study of the development of science process skills, ability in analyzing and scientific mind during the past decade, found that in section of science process skills of students has been developed in a low level. Akinbobola and Afolabi (2010 : 234) analyzed the science process skills of African students in Nigeria by ex post facto study method during 1998 – 2007 and found that most of students lacked of integrated science process skills which impacted in seeking of scientific knowledge and problem solving in both scientific related and unrelated situation. Walters and Soyibo (2001 : 133) explored integrated science process skills of students in Jamaica found that students had integrated science process skills in low level. Chaiyen, Boonsawansong and Yutakom (2007 : 11) studied integrated science process skills in the chemical equilibrium of students in upper secondary school and found that students had no success in developing of science process skills in which the skills that caused problems include defining operationally skills, experimenting skills in conclusion, identifying and controlling variables, experimenting skills in gathering and analyzing data and interpreting data, and concluding skills respectively. The ability in analyzing reflected that Thai students also had the ability to analyze in a low level. It could be seen from the results of external quality assessment which found that the standard was not

certified quality standard as the fourth highest standard of the learner were ability to analytical thinking, synthesis thinking, critical thinking, creative thinking, and reflection and visionary thinking. (Office of Nation Education Standards and Quality Assessment (Public Organization). 2010 : 22 - 25) Therefore, it is undeniable that there is a need to develop a learning process to expand students' science process skills and ability in analyzing to a higher level. Concerning to scientific mind, although none of the result of the studies clearly supports that scientific mind had been developed. However, it was likely to have a feature that should be further developed relating to science process skills and ability in analyzing. This was due to the fact that these features associated with feeling, ideally and expressive behavior which would lead to knowledgeable accuracy and credibility.

From studying the results of researches that associated to the development of science process skills, ability in analyzing and scientific mind showed that these features were developed through a variety of teaching methods, teaching models, or innovation. Moreover, we found that the most popular approach used in science teaching was 5E instructional model. This instructional model based on constructivism theory which is learning process that emphasizes on the learners to resolve and gain knowledge by themselves under the context of meaningful authentic. (Thumthong. 2013 : 36) In the field of measurement and evaluation, preliminary studies had not shown any application of assessment methods or evaluation model which could assist in the development of science process skills, ability in analyzing and scientific mind directly. Rather, they were seen as a tool to measure knowledge, skills, or attributes arising from the methods, models, or innovations that were developed by the researchers only. Measurement and evaluation was part of learning process as a tool that helped to reflect how much the instruction achieved aims. Moreover, it also provided key ideas for developing students from inappropriate behavior. Currently, an authentic assessment is an alternative way of assessment due to the fact that this assessment is for developing learners rather than judging them. In addition, it also switch from selecting answer choices to practicing task or creating job in the real situation. It tends to change of testing knowledge and memory to create and apply of knowledge which shifting from focusing on the role of teacher to the learners expressing their roles more. (Office of the Basic Education Commission. 2006 : 2-3). Apart from teaching methods and teaching models as found in researches in general, the researcher has applied concept of authentic assessment for developing science process skills, ability in analyzing and scientific mind in this study.

From the above introduction, the researcher's concept is to develop a program for enhancing integrated science process skills, ability in analyzing and scientific mind of students by aiming that the program would integrate authentic assessment for driven

students to be able to learn, practice, self-assess, self-reflect and develop themselves. As a result, the three features were in higher level and can be applied for seeking of knowledge and problem solving systematically.

Objectives

The objectives of this study were:

- 1) To develop a program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment.
- 2) To trial a program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment for study effectiveness of program.

Research hypothesis

The students' integrated science process skills, ability in analyzing and scientific mind after participating in the program was higher than before.

Research Methodology

Population and samples

Population were 3,919 Mathayomsuksa 4 students from thirty one secondary schools in Loei province, in 2014.

Samples consisted of 31 Mathayomsuksa 4 students from Phuluang Wittaya School in 2014 that were selected by cluster random sampling by using the classroom as a unit in random order. The samples were sampling as following:

- 1) Selected schools in Loei were defined by following characteristics:
 - 1.1) The schools that teach Science–Math program for two or more classes.
 - 1.2) The school that result of Ordinary National Education Test (O-NET) in the ninth grade of science was lower than the national level.
 - 1.3) The school that was willing to assist the research trial and data collection.
- 2) From the process of selection, Phuluang Wittaya School that has two classrooms of Science–Math program was selected. After that the researcher tested integrated science process skills, ability in analyzing and scientific mind of both classroom, and tested different of these attribution by t-test Independent samples. The result found that overall of feature of two rooms had no different.

3) Researchers randomly selected students into the sample by using the classroom as a unit in random order. The students made up of one of the 31 people on trial for using a sample program on this occasion.

Variables

Independent variable was learning by using the program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment.

Dependent variable included of integrated science process skills, ability in analyzing, scientific mind, and students' satisfaction to participate in the program

Research tools

Integrated science process skills test, integrated science process skills performance assessment, ability in analyzing test, scientific mind test and satisfaction questionnaires were conducted for data collection in this study.

Procedure

This study was divided in to three phase as following:

Phase 1 : Investigation of problems, causes and needs assessment in the development of science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students by using the method of exploratory sequential design. The process started from measurement science process skills, ability in analyzing and scientific mind of 362 Mathayomsuksa 4 students in Loei province, Thailand to process the problems arising from instruction process. After that there was collection of qualitative data by doing the random of the small, medium and large size schools that were collected the data before for observing the process of teaching and learning, context of learning, and interviewing teachers and students. The data was analyzed for causes that affected development of the three features of students before being classified by the characteristics of students, design learning, learning process, and learning environment. Then, the causes are identified to create the assessment tool for developing features of the three aspects of students and collecting quantitative data from 35 chemistry teachers of the schools in Loei province. The data was evaluated in order to develop and found that the highest need of teachers in developing students for enhancing three features was the design learning and learning process.

Phase 2 : Development a program for enhancing integrated science process skills, ability in analyzing and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment was established. The information of needs in phase 1 was selected to be a framework to interview for guideline development. The information was acquired from six Chemistry teachers who had experiences and expertise in science field in Loei province. Moreover, there was the studies of approach to develop features in all three

aspects from the concept of educators. Then, it was a combination of all approaches to develop and create the draft of program by cooperating with five chemistry teachers who are interested in developing the program. The draft program was determined of appropriate elements by eight experts. Later, the researcher improved elements of the program according to the advice of the experts before trying out the program with Mathayomsuksa 4 students accounting for thirty five students in order to evaluate and improve the program before trialing with the samples.

Phase 3 : Trial a program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment for studying the effectiveness of the program by considering from the comparison of the integrated science process skills, ability in analyzing, and scientific mind between before and after students' participation of the program and students' satisfaction to participate in the program. The study's design for trial the program was one group pretest-posttest design by trialing with thirty one Mathayomsuksa 4 students from Phuluang Wittaya School, the duration of trial the program was for 40 hours.

Data Analysis

The data from tests and questionnaires was analyzed by mean and standard deviation. The hypothesis was determined by t-test dependent samples.

Results and conclusion

The results showed that:

1. A program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment was the program that focuses on developing three features of students through experimental activities which consisted of activities to provide basic knowledge of integrated science process skills and basic for using experimental equipment, five experimental activities (included chromatography, properties of carbohydrates, acid – base on a daily, natural indicator, and electrical conductivity, respectively) and processing and presentation of products or jobs that they are interested in. The process of learning in each experimental activities was integrated authentic assessment into the 5Es learning cycle consisting of self-assessment and goal setting, plan do and check, analysis and synthesis, present and discussion, summarize and evaluate themselves, and creating product. During learning process, students would learn together as a group and were a key role in self-assessment for analyzing failures which later lead to self-improvement until they reach objectives in each activity. The content that used in experimental activities has been closed and associated to daily life of students. This would motivate students to see the importance of science that

related to their lives simultaneously with three aspects. Assessment of the experts found that the components of the overall program were at the most appropriate level ($\bar{x} = 4.52$ S.D. = 0.53) and the result of the tried - out of the program showed that the program could promote students to be better in science process skills, ability in analyzing and scientific mind and they could be determined to be in a good level.

2. After participating in the program, the integrated science process skills, ability in analyzing and scientific mind of the students, the result was higher than before with at .05 significance level. The details are shown in table 1

Table 1 A comparison integrated science process skills, ability in analyzing and scientific mind, of students between before and after participated the program.

Variable	Test	\bar{x}	S.D.	t	P
Integrated science process skills	Post-test	22.85	2.48	16.14*	0.000
	Pre-test	14.69	2.69		
ability in analyzing	Post-test	24.06	3.19	13.01*	0.000
	Pre-test	15.90	3.34		
scientific mind	Post-test	20.21	1.14	13.87*	0.000
	Pre-test	18.26	1.70		

* Difference is significant at .05 levels

3. Students' satisfaction to participate in the program as a whole was in high level ($\bar{x} = 4.38$ S.D.= 0.55) classifying of aspects been satisfied in the process was at the highest level ($\bar{x} = 4.61$ S.D. = 0.56), input was in high level ($\bar{x} = 4.31$ S.D. = 0.55) and output was in high level ($\bar{x} = 4.24$ S.D. = 0.54). The details are shown in table 2

Table 2 Students' satisfaction to participate in the program

Satisfaction	\bar{x}	S.D.	Level of satisfaction
Input	4.31	0.55	High
Process	4.61	0.56	Highest
Output	4.24	0.54	High
Over all	4.38	0.55	High

From a result of this study, it can be concluded that the program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment effected to students' integrated science process skills, ability in analyzing, and scientific mind was increased to higher level as the statistic show the significance. Moreover, the program made students satisfy and willing to participate in the program as a whole in high level.

Discussion

As a result of this study, it was found that the program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment effecting to students' integrated science process skills, ability in analyzing, and scientific mind was in higher level as statistically significant. This is probably due the following reasons.

Firstly, the consistency of three features by integrated science process skills is in higher order for seeking knowledge of scientist including of formulating hypotheses, defining operational system, identifying and controlling variables, experimenting, interpreting data, and concluding (Praedum. 2001). The ability in analyzing is ability to classify element of situations or contents that include how it is relevant, what it is structured, and others (Bloom and others. 1956). These components extremely relate with integrated science process skills, therefore, when integrated science process skills were improved, the ability in analyzing scientific would be positive changed and effected to develop scientific mind. This is because the scientific mind is a feature that occurs in student when they learn both contents and processes in science (Chundapradit. 1994)

Secondly, the program focused on developing students for science process skills, ability in analyzing, and scientific mind by using the practice through experiment activities that were related to scientific method for seeking knowledge or problem solving (Roadrangka and Nuankeaw. 1999). Therefore, if the students often practice their science process skills, their scientific mind will be increased. Besides, the practice through experiment could develop ability in analyzing of students because experiment activities made them practice in order to notice, note, set the question, set hypothesis, find answers, and check the answers and analyze relation of what happening around them. (Ministry of education. 2006 ; cited Wasri, P. n.d.)

Thirdly, the process of learning in the program adapted from 5Es learning cycle and integrated authentic assessment in the process focused on self-learning though doing activities in situation that associated with daily life and context close to student. Therefore, during the learning process, the focus were on group working and self – assessment for improving themselves to set and could acquire data from learning to create products that reflected their knowledge, skills and attitudes. This process of learning was done according the condition of constructivist learning theory (Thumthong. 2013 ; cited Bednar et. al.. 1995) including learning by doing, the process that would help the learner create meaning in their learning from cooperation between the learners. This method encourages the learners to develop knowledge and skills through sharing variety ideas while they discussed in groups. The results reflected that during this process the learners would have to modify their own knowledge structure. The appropriate learning should occur in the real world or reflect the context of the actual condition which will lead to the knowledge associating to daily life that able to create the knowledge and skills from the learning.

Besides, the effects on integrated science process skills, ability in analyzing, and scientific mind to increase, students who participated in the program were satisfied at high level , cause of activities in the program emphasized to practice with experiment activities were designed to associated real life, as a result, learning becomes meaningful. The content of activities was not too hard so students did not get tired or discouraged to learn. Together with the emphasis on learning in groups, students' interaction with peers within group and between groups allowed students to learn happily. Students participated in evaluating themselves and others which led to continue improvement of their failures for having better attitudes and skills. Moreover, these process also involved the creation of product and presentation, especially in the section of the exhibition to present an overview of learning in classroom reflecting in the annual local festival “Payachang – Nang phom hom festival” of Phuluang district Loei. This event brings pride to student from what they have done. As a result, students are satisfied to attend the activities in the program in high level.

Recommendation

In implementing the program for enhancing integrated science process skills, ability in analyzing, and scientific mind of Mathayomsuksa 4 students through the integration of authentic assessment to achieve aims efficiently. Teachers should focus on the following issues:

1. Teacher should understand the program clearly in order to process the program smoothly.
2. Teacher should understand the role of the teacher she/he is a helper or an adviser who facilitates learning for students not who teaches or gives answers to the student. While the students have important role in learning that is for developing themselves.
3. Teacher should make students aware of the importance of assessment and reflection of learning to keep students' interested and eager to practice in such procedures which will significantly lead to true development.
4. Assessment and reflection of students in the early stages of the learning activities of the program may be difficult for students. However, we will see what can be done better on several activities later. The teacher should provide time for students to learn, assess, and reflect gradually until it is able to run automatically.
5. In learning procedures, especially in the stage of planning, performing, and monitoring, analysis and synthesis should be flexible and allow time consuming to an appropriate which will bring great opportunities for students to fully learn and develop themselves. However, it mustn't be too much avoidance in completing task which may cause more stressful or discouragement of students to learn.
6. The cooperative group learning activities and circulating students to act can help to promote the involvement of students for developing themselves equally. So, teachers should give priority to this process to determine whether student has circulation of ideas and practice within the group or not.

References

- Akinbobola, A. O., and Afolabi, F. "Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics Practical Examinations in Nigeria," **American-Eurasian Journal of Scientific Research**, 5 (4), 234 - 240, 2010.
- Bloom, B. S. and Others. **Taxonomy of Educational Objectives**. New York : David McKay Co., Inc, 1956.
- Chaiyen, Y., Boonsawansong, P. and Yutakom, N. "Integrated Science Process Skills on Chemical Equilibrium of High School Students from Schools in Chanthaburi Province," **Kasetsart Journal : Social Sciences**, 18(1), 11 - 22, 2007.
- Chundapradit, M. **Science process skills for science teachers**. Maha sarakham : Department of curriculum and instruction, Faculty of education, Rajabhat Maha sarakham Institute, 1994.

- Ministry of Education. **Operational guidance documents instructional reform by attributing the Ministry of Education “2006 Years of teaching reform” approach to the curriculum to develop analytical thinking skills.** n.p., 2006.
- Ministry of Education. **Strands and learning standards learning area of science B.E. 2551 (A.D. 2008).** n.p., 2008.
- Roadrangka, V. and Nuankeaw, J. **The development thinking of students through science process skills activities.** (2nd ed.). Bangkok : Institute of academic development, 1999.
- Office of Nation Education Standards and Quality Assessment (Public Organization). **External quality assessment report. (2006 – 2010).** Bangkok : Match point, 2010.
- Office of the Basic Education Commission. **Guideline for authentic assessment.** Bangkok : The Express Transportation Organization of Thailand, 2006.
- Praedum, S. **Science process skills.** Ubon Ratchathani : Faculty of Education, Ubon Ratchathani University, 2001.
- The Institute for the Promotion of Teaching Science and Technology. **Assessing science.** Bangkok : Se-education, 2012.
- Thumthong, B. **Theories and Development of Instructional Model.** Bangkok : S. printing Thailand Factor, 2013.
- Walters, Y. B., and Soyibo, K. “An Analysis of High School Students' Performance on Five Integrated Science Process Skills,” **Research in Science & Technological Education,** 19(2), 133 - 145, 2001.