THE DEVELOPMENT OF A DISTANCE TRAINING PACKAGE FOR SECONDARY SCHOOL TEACHERS ON THE TOPIC OF TEACHING TO DEVELOP SCIENTIFIC INQUIRY SKILLS

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ABSTRACT

This research was guided by three aims: (1) to develop a distance training package for secondary school teachers on the topic of teaching to develop scientific inquiry skills, (2) to compare the teachers' comprehension of teaching for the development of the skills before and after using the package, and (3) to study the teachers' satisfaction with the package. The research sample comprised thirty (30) secondary school science teachers in Nonthaburi province, Thailand, obtained by stratified random sampling. Three research instruments were used: the distance training package, comprehension tests on teaching for the development of the skills, and a questionnaire to assess the teachers' satisfaction with the developed training package. Statistics used for data analysis were the percentage, mean, standard deviation, and t-test. The research findings revealed that there were six steps in the development of the the package, namely (1) identifying the objectives of the Distance Training Package, (2) reviewing the literature, (3) constructing the package, (4) analysing its validity, (5) testing, and (6) improving the developed package. The Distance Training Package is composed of instruction and activity booklet and an accompanying manual. The efficiency of the package was established as 82.17/83.00. Teachers' comprehension of Scientific Inquiry Skills after using the training package is significantly higher than before training at .05 level. Teachers' satisfaction based on the post training survey showed higher ratings.

Keywords: *Distance training package, Teaching, Scientific inquiry skills, Secondary school science teachers*

INTRODUCTION

The learning process in the secondary school science classroom should emphasise connecting knowledge with skills, possessing important skills for investigation, and constructing a body of knowledge by using the process of scientific inquiry and problem solving (Office of the Basic Education Commission, Ministry of Education, 2008). Scientific inquiry is a sophisticated activity, which includes observing, questioning, investigating information from books or other resources, planning investigation, reviewing evidences from experiments, using tools for collecting, analysing and interpreting data, drawing answers, explanations and predictions, and communicating results from scientific inquiry (National Research Council [NRC], 1996).

Scientific inquiry skills (SISs) consist of both practical science process and knowledge about process (Flick & Lederman, 2006). SISs normally involve the following six actions: generating questions or problems to be solved, brainstorming solutions, formulating hypotheses to be tested, selecting procedures and performing them according to investigative processes, collecting and recording thorough observations to generate the appropriate conclusions, and communicating and making decisions among claims and evidences through scientific argumentation. Moreover, NRC (2000) lists five important characteristics of scientific inquiry, as follows: scientific questions that interest the students; evidences that are collected by students, which help them to develop and evaluate explanations related to scientific questions; explanations generated from evidences by students to answer scientific questions; evaluation of explanations, which includes alternative explanations that reflect scientific understanding; and communication and decision-making in relation to the generated explanations. Science teachers can develop SISs of the students via a variety of learning media, for example, using the local environment for the students to observe, measure, and collect leaves in the field, measure water acidity, or explore the height of a mountain. In addition, teachers can be trained to teach SISs to students by using distance training packages (DTP).

A DTP is formatted to transmit understanding, which helps people to learn and change behaviour. It is planned for training systematically. Also, it can be used to train for particular objectives in a required format, for large numbers of learners, learning by themselves by going through the assigned content, without time and place limitations (Brahmawong, 2013). A DTP is made up of two elements: the results from distance training development, including manual, media, activities, and evaluation and the training package as a system, including input, process, measurement and behavioural evaluation (Brahmawong, 1994). DTP development includes assignation of objectives, writing behavioural objectives, rearranging the presentation, performing the steps of production, media selection, and evaluation (Brahmawong, 1994; Sukpredee, 2004; Pholyothin, Buagerd, & Horadal, 2005). Therefore, DTPs can be used to develop the abilities of teachers to teach SISs. In the present study, a DTP was applied to secondary school science teachers in Nonthaburi, who were willing to extend their own practice and development to other regions.

LITERATURE REVIEW

There is a significant amount of research that compares students' learning in classrooms which promote scientific inquiry against their learning in conventional classrooms. Alberts (2000) found that learning through scientific inquiry can improve retention. Johnson, Moher, Cho, Edelson and Russell (2004) describe how students learn SISs via virtual fields. The students collected data in computers, integrated data in classrooms, studied patterns of data, and formulated explanations of data patterns as part of classroom practice in inquiry-based learning.

Teaching and learning management for the development of SISs, thus, should be aimed at determining learners' ability to acquire knowledge about processes and their ability to perform according to those processes. There are many teaching methods that can be used to develop students' SISs, for example, problem based learning, project based learning, or inquiry cycles. The most popular inquiry cycle in Thailand is 5Es/7Es, which were implemented in this study. The 7Es inquiry cycle were proposed by Eisenkraft (2003).

Science teachers in Nonthaburi province developed their conceptual understanding of teaching science process skills after using a DTP (Pinsuwan, 2014). Several science process skills are relevant to SISs; thus, the science teachers should be developing an understanding of SISs at a higher level. Furthermore, using DTPs could develop these closely related skills (Pinsuwan, 2014).

Therefore, this study was guided by two research questions: "*Does the distance training package (DTP) improve teachers' comprehension of teaching for the development of SISs?*" and "*Were the teachers satisfied with the DTP?*" Following this, the research objectives were to (1) develop a DTP for secondary school science teachers on the topic of teaching for the development of scientific inquiry skills (SISs), (2) compare the teachers' comprehension of teaching for the development of SISs before and after using the DTP, and (3) study the teachers' satisfaction with the DTP.

RESEARCH METHODOLOGY

The research population used in this study were secondary school science teachers in the Nonthaburi province of Thailand, comprising 290 teachers in 18 schools. For the efficiency tests, three science teachers used for one-to-one testing and six science teachers used for group testing were selected through purposive sampling.

The total research sample used in this study comprised 30 secondary school science teachers, obtained from stratified random sampling. A total of eight schools throughout six districts were randomly sampled according to the proportionate size of the district. Then, three or four science teachers in each school were randomly sampled.

Of the 30 participants, 5 were male (16.67%) and 25 female (83.33%). The average age was 39.45 years (S.D. = 11.55). Their educational backgrounds (major subjects) were Bachelor of Science (Chemistry, Biology, Physics, and General Science), Bachelor of Education (Chemistry, Biology, Physics, and General Science), Master of Science (Chemistry, Biology, and Physics), and Master of Education (Curriculum and Learning Innovation). They had been teaching science for an average of 14.88 years (S.D. = 11.74). Moreover, their academic positions included teachers, professional teachers, and specialist teachers. They taught science (Grades 7-9), and chemistry, biology, and physics (Grades 10-12) in the 2015 academic year.

The instruments used in this research were the DTP, DTP evaluation form, pre-test and post-test, and a questionnaire on the teachers' satisfaction with the DTP.

The researcher developed the DTP according to the following steps:

(1) Identified objectives of the DTP.
(2) Studied documents and related research.
(3) Constructed the DTP, assessed the quality of activities in the DTP, checked appropriateness of activities, improve activities according to suggestions of the three experts to meet IOC of 0.67-1.00.
(4) Quality of the DTP was assessed by three experts in the field of teaching for the development of SISs. The researcher then checked appropriateness of the DTP. Improved the DTP according to suggestions of three experts to meet IOC of 0.67-1.00. Examined quality of the DTP as one-to-one by three science teachers, improved and examined quality of the DTP as group by six science teachers, and improved and examined quality of the DTP as field by 30 science teachers.
(5) Tested the DTP with the selected 30 science teachers and recorded the results.
(6) Improved the DTP based on post-analysis of recorded results.

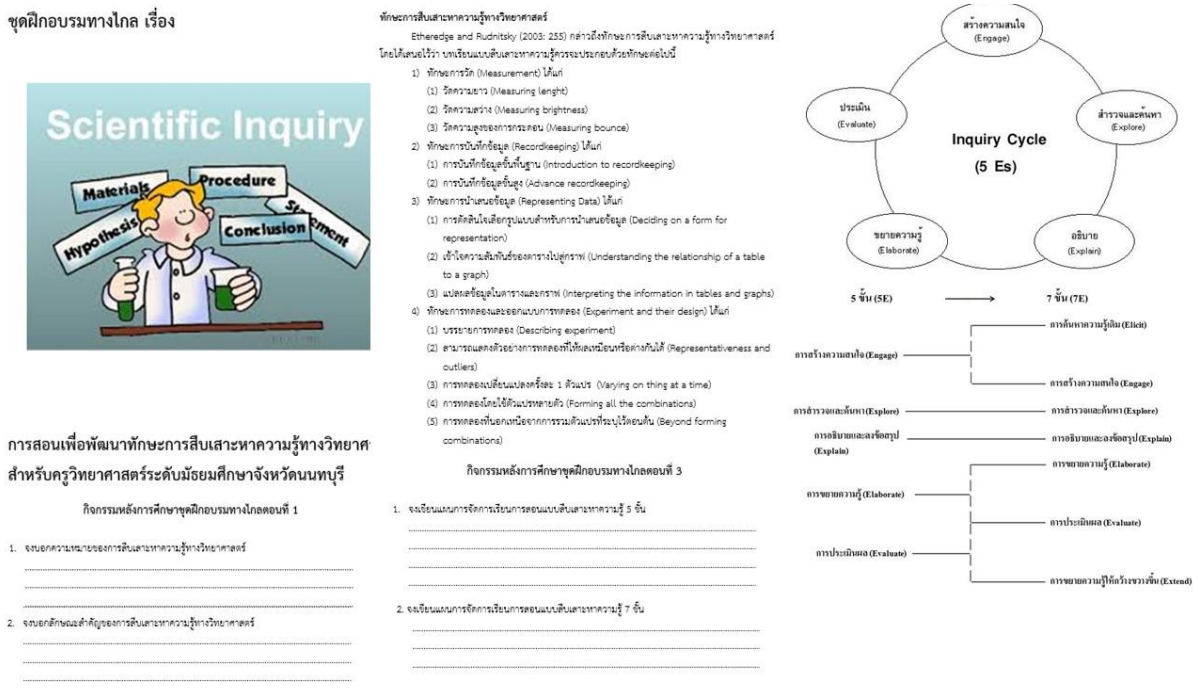

Figure 1: Example of pages in the DTP

In developing the comprehension tests, the following steps were performed:

(1) Studied documents related to the development of test instruments.
(2) Analysed objectives of the DTP in order to construct tables of test specifications, which involved questions about teaching for the development of SISs.
(3) Determined type of the test as essay, 20 items, to assess the teachers' understanding before and after training.
(4) Constructed the tests as described in the test specifications table.
(5) Delivered the tests to three experts to consider congruency. IOC of 0.67-1.00 was obtained.
(6) Improved the tests according to the experts' suggestions. Implemented the tests with 20 science teachers and scored the answer sheets.
(7) Analysed quality of the tests. The pre-test showed a difficulty index of .25-.75, a discrimination index of .30-.70, and a reliability index by using Cronbach's α of .79. The post-test showed a difficulty index of .31-.58, a discrimination index of .23-.88, and a reliability index by using Cronbach's α of .76.
(8) Used the tests for data collection.

The researcher developed the questionnaire to assess the teachers' satisfaction with the DTP, according to the following steps:

(1) Studied documents about construction of satisfaction questionnaires. In this research, a 5-point Likert scale was used.
(2) Wrote statements expressing opinions. The response scale listed the following: highest, high, medium, low, and lowest.
(3) Checked and organised statements into groups.
(4) Delivered the questionnaire to three experts to consider appropriateness of statements and language used before publishing.

The data collection was performed as follows:

(1) A pre-test was performed before the teachers used the DTP. The teachers took the 10-item test, which lasted 30 minutes, to measure their understanding of teaching for the development of SISs.

(2) The teachers received the DTP and manual on the topic of teaching for the development of SISs 30 days before attending the training workshop so that they would be able to prepare.
(3) The teachers studied the training package for 30 days.
(4) A two-day training workshop was conducted. The workshop activities included recapitulation about teaching for the development of SISs by the researcher, practical activities for teachers to develop inquiry-based teaching methods, presentations on relevant inquiry methods, and concluding remarks by the researcher.
(5) A post-test was then carried out. The teachers took a 10-item, 30 minute test, which was designed to determine their comprehension of relevant scientific inquiry teaching methods.
(6) The teachers answered the questionnaire on their satisfaction with the DTP.

Calculation of efficiency (E_1/E_2)

$$E_1 = \frac{\frac{\sum x}{N}}{A} \times 100$$

E1 represents the efficiency of the process.

$\sum X$ = Total score of activities, assignments or reports during learning
N = Number of students/learners
A= Full scores of formative evaluation such as scores from activities, assignments, and reports etc.

$$E_2 = \frac{\frac{\sum F}{N}}{B} \times 100$$

E_2 represents the efficiency of the products

$\sum F$ = Total score of products after learning
N = Number of students/learners
B= Full scores of summative evaluations such as scores from post-tests or final works assigned to the students.

Efficiency criteria (E_1/E_2) of DTP is usually established at 80/80 for content knowledge. The result from efficiency testing should not exceed 2.5% of the criteria or should not exceed ± 2.5 from efficiency criteria (Brahmawong, 2013).

RESEARCH FINDINGS

Research findings are presented in relation to the three research objectives, as follows: (1) results of the development of a DTP for secondary school science teachers on teaching for SISs development, (2) results of comparison of the teachers' comprehension of teaching for the development of SISs before and after using the DTP, and (3) results of studying the teachers' satisfaction with the DTP.

Research Finding 1

This section presents the results of development and efficiency of the DTP on teaching for SISs development for secondary school science teachers in Nonthaburi province.

The DTP document includes the following: a title, rationale, table of contents, concepts, objectives, and three chapters of content.

Chapter 1 is about scientific inquiry, and includes the table of contents, definition of scientific inquiry, important characteristics of scientific inquiry, SISs, and activities to be performed after studying the DTP.

Chapter 2 is about learning management through scientific inquiry, and includes the table of contents, definition of learning management through scientific inquiry, background of learning management through scientific inquiry, format of learning management through scientific inquiry, and activities to be performed after studying the DTP.

Chapter 3 gives examples of learning management through scientific inquiry, and includes the table of contents, examples of learning management plans through scientific inquiry using the 5Es cycle, examples of learning management plans through scientific inquiry using the 7Es cycle, and activities to be performed after studying the DTP.

Handouts provided alongside the DTP include an explanation of the DTP and its objectives, commentary of using the DTP, schedule of workshop training, as well as handouts, and evaluations used in training.

The efficiency of the DTP on a one-to-one level was tested with three secondary science teachers. The result revealed an efficiency of 68.33/62.67, as shown in Table 1.

Table 1: One-to-one testing of the DTP

Duration	Number of teachers	Percentage	S.D.
While using the DTP	3	68.33	2.02
After using the DTP	3	62.67	1.80

Table 2 displays the analysis of efficiency of the DTP after improvement as a group tested with six secondary science teachers. The result revealed an efficiency of 73.33/70.00, as shown in Table 2.

Table 2: Group testing of the DTP

Duration	Number of teachers	Percentage	S.D.
While using the DTP	6	73.33	2.36
After using the DTP	6	70.67	2.02

Table 3 displays the analysis of efficiency of the DTP after improvement as field tested among 30 secondary science teachers. The result revealed an efficiency of 82.17/83.00, as shown in table 3.

Table 3: Field testing of the DTP

Duration	Number of teachers	Percentage	S.D.
While using the DTP	30	82.17	1.75
After using the DTP	30	83.00	2.02

Table 4 displays the analysis of the mean difference between the scores obtained from participants while using the DTP and after using the DTP, which revealed that there was no significant difference at .05 level, as shown in Table 4.

Table 4: Mean difference between results while and after using the DTP

Duration	n	$\overline{X}$	S.D.	$\bar{d}$	S_d	t	Sig.
While using the DTP	30	16.43	1.41	.167	.913	1.000*	.326
After using the DTP	30	16.60	1.85				

p*>.05

Research Finding 2

This section discusses the comparison of the teachers' comprehension of teaching for the development of scientific inquiry skills before and after using the DTP.

The participants' pre-test mean score was 8.08 (S.D. = 3.89), while their post-test mean score was 16.60 (S.D. = 1.85). The results from the t-test for dependent samples revealed that participants' comprehension after using the DTP was significantly higher than their comprehension before using the DTP, at .05 level, as shown in Table 5.

Table 5: Comparison of participants' comprehension of teaching for the development of SISs before and after using the DTP

Duration	N	$\overline{X}$	S.D.	$\bar{d}$	S_d	t	Sig.
Before using the DTP	30	8.08	3.89	8.52	4.13	11.288*	.000
After using the DTP	30	16.60	1.85				

p*<.05

Research Finding 3

The participants' satisfaction with the DTP about teaching for the development of SISs for secondary school science teachers in Nonthaburi province was at the highest level as shown in Table 6.

Table 6: Participants' satisfaction with the DTP

Items	Mean	S.D.	Meaning
Chapter 1 : Scientific Inquiry	4.64	0.50	High
1. Contents are appropriate for science teachers.	4.53	0.51	High
2. Contents are appropriate for assigned activities.	4.60	0.50	High
3. Sequences of content relation are appropriate.	4.67	0.55	High
4. Language used is clear and easy to understand.	4.73	0.45	High
5. Contents are appropriate for time for learning the DTP.	4.67	0.48	High
Chapter 2 : Learning management through scientific inquiry	4.82	0.39	High
1. Contents are appropriate for science teachers.	4.70	0.47	High
2. Contents are appropriate for assigned activities.	4.90	0.31	Highest
3. Sequences of content relation are appropriate.	4.76	0.43	High
4. Language used is clear and easy to understand.	4.87	0.35	Highest
5. Contents are appropriate for time for learning the DTP.	4.87	0.35	Highest
Chapter 3: Examples of learning management through scientific inquiry	4.72	0.52	High
1. Contents are appropriate for science teachers.	4.70	0.53	High
2. Contents are appropriate for assigned activities.	4.70	0.53	High

Items	Mean	S.D.	Meaning
3. Sequences of content relation are appropriate.	4.67	0.55	High
4. Language used is clear and easy to understand.	4.77	0.50	High
5. Contents are appropriate for time for learning the DTP.	4.77	0.50	High
Overall image of distance training package	4.79	0.44	High
1. Content of DTP benefits science teachers.	4.77	0.50	High
2. An accordance of content in each chapter is appropriate.	4.77	0.43	High
3. Activities at the end of each chapter are clear and easy to understand.	4.83	0.38	High
Grand total mean	4.74	0.47	High

DISCUSSION

The DTP was created in accordance with Brahmawong (1994) and Sukpredee (2004), which involved the following developmental steps: (1) analysis of contents, (2) assignment of topics, concepts, objectives, activities, and evaluation, and (3) efficiency testing and improvement of the DTP. The DTP components corresponded to Baigasuyee (1993). The DTP was composed of contents and pictures for three chapters as follows: Chapter 1: Scientific inquiry, Chapter 2: Learning management through scientific inquiry, and Chapter 3: Examples of learning management through scientific inquiry, which contained explanations of principles and presented examples of practice activities. The learning management plans in Chapter 3 provided examples using the 5Es inquiry cycle and the 7Es inquiry cycle. Moreover, the activities at the end of each chapter corresponded to the concept of constructing the DTP. Baigasuyee (1993) proposes that production of media used to promote knowledge should contain pictures and activities that are of interest to the learners. The experts' opinions all confirmed that content in the DTP was related in structure. This would help the learners to self-study the DTP and practice scientific inquiry skills effectively.

The participants were able to learn via the DTP and perform the activities after each chapter autonomously. This caused higher-level comprehension about inquiry-based secondary science teaching methods since the efficiency of the DTP was established as 82.17/83.00. After testing the difference of E_1/E_2, it was found that there was no significant difference at .05 level, and the efficiency of the DTP was as recommended by Brahmawong (2013).

The results showed that the participants had significantly higher comprehension of scientific inquiry teaching skills after using the DTP when compared to their comprehension before using the DTP, at the .05 level. This can be attributed to the clear explanations in each chapter and the provision of several examples of learning management plans. According to the survey results, the teachers' satisfaction with the DTP was at the highest level. The results corresponded to those of previous studies, namely by Visavateeranon, Chindanurak, Kamchaturas and Chaowakeeratipong (2011), Pinsuwan (2014), Pholyothin, et al.)2005(, Makkasman, Horadal, Pholyothin, and Iamsupasit (2008), and Ratanapan (2009).

CONCLUSION

The distance training package (DTP) on the topic of teaching for the development of SISs for secondary school science teachers in Nonthaburi province comprised the DTP instruction and activity booklet and an accompanying manual. The DTP's efficiency was established as 82.17/83.00. After using the DTP, the participants' comprehension of teaching for the development of SISs was significantly higher than their comprehension before using the

DTP, at .05 level. The teachers' satisfaction with the DTP was at the highest level. Suggestions for further studies are as follows:

(1) Follow-up research on secondary school science students' inquiry skills.
(2) Improvement of the DTP by using Information and Communication Technology (ICT) as major media.

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