A Study on Process for Developing Research Skills in the Aspect of Logical Thinking by Using Exercises as Teaching Materials of Students in Faculty of Education at Phetchaburi Rajabhat University [*]

การวิจัยกระบวนการพัฒนาทักษะการวิจัยด้านการคิดเชิงเหตุและผล ด้วยเอกสารประกอบการสอนประเภทแบบฝึก ของนักศึกษามหาวิทยาลัยราชภัฏเพชรบุรี

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Abstract

The objective of this research was to develop research skills in the aspect of logical thinking by using exercises as teaching materials of students in Faculty of Education at Phetchaburi Rajabhat University. The research samples consisted of 197 first year students, majoring in social studies and physical education, who were studying Thai Education and Educational Laws. There were three steps in conducting research, namely step 1 identification of logical thinking elements, step 2 construction of relationship among those elements, and step 3 application of logical thinking in problem solving. The research tools were teaching materials consisting of 12 exercises for practice. The quantitative data were analyzed by using frequency, percentage, standard deviation, mean where X means 100% scores, Y means 50–99% scores and Z means less than 50% and independent t-test.

The research results were as follows:

1. For the percentage of students being developed on research skills in the aspect of logical thinking at the levels of X, Y, and Z, it was found that, when considered through step 3, percentage of students in each major at X level overall increased and the percentages of students majoring in social studies and physical education at this level were

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78.61 and 68.35 respectively. The percentages of students in both majors at X level in step 1, 2 and 3 were 3.02, 8.48 and 73.46, at Y level were 94.94, 82.74 and 22.98 and Z level were 2.01, 8.72 and 4.86 respectively.

2. The mean scores of research skills in the aspect of logical thinking of students majoring in social studies and of those majoring in physical education in step 1 were different with statistical significance at the .01 level, whereas those in step 2 and 3 were different without statistical significance.

Keywords: Development process, Research skill, Logical thinking, Exercises as Teaching Materials

บทคัดย่อ

การวิจัยในครั้งนี้มีวัตถุประสงค์เพื่อพัฒนาทักษะการวิจัยด้านการคิดเชิงเหตุและผลด้วยเอกสารประกอบการสอนประเภทแบบฝึก ของนักศึกษามหาวิทยาลัยราชภัฏเพชรบุรี กลุ่มตัวอย่างที่ใช้ในการวิจัยประกอบด้วย นักศึกษาชั้นปีที่1 สาขาสังคมศึกษาและสาขาพลศึกษา ที่เรียนในรายวิชาการศึกษาไทยและ กฎหมายการศึกษา รวม 197 คน ในการวิจัยนี้สร้างแบบฝึก 3 ขั้นตอน ได้แก่ การจำแนกองค์ประกอบของการคิดเชิงเหตุและผล การสร้างความสัมพันธ์ระหว่างองค์ประกอบ และการประยุกต์ใช้ความคิดเชิงเหตุและผลในการ แก้ปัญหา เครื่องมือที่ใช้ในการวิจัย คือ เอกสารประกอบการสอนประเภทแบบฝึก จำนวน 12 แบบฝึก การวิเคราะห์ข้อมูลเชิงปริมาณด้วยสถิติ ความถี่ ร้อยละ ค่าเฉลี่ย โดยที่ X,Y และ Z หมายถึง มีคะแนนร้อยละ 100, 50 - 99 และน้อยกว่า 50 และการวิเคราะห์ค่าทีแบบอิสระ

ผลการวิจัยพบว่า

1. ร้อยละของนักศึกษาที่ได้รับการพัฒนาทักษะการวิจัยด้านการคิดเชิงเหตุและผลจากระดับ X, Y และ Z เมื่อพิจารณาถึงขั้นที่ 3 มีร้อยละของระดับ X ที่เพิ่มขึ้น โดยรวมแต่ละสาขา พบว่า เรียงลำดับจากมากไปหาน้อย ได้แก่ นักศึกษาสาขาสังคมศึกษา เท่ากับ 78.61 และสาขาพลศึกษา เท่ากับ 68.35. โดยรวม 2 สาขาจากขั้นที่ 1 ถึงขั้นที่ 3 มีร้อยละของระดับ X เท่ากับ 3.02, 8.48 และ 73.46 ร้อยละของระดับ Y เท่ากับ 94.94, 82.74 และ 22.98 และร้อยละของระดับ Z เท่ากับ 2.01, 8.72 และ 4.86

2. การวิเคราะห์ความแตกต่างของค่าเฉลี่ยของการพัฒนาทักษะการวิจัยด้านการคิดเชิงเหตุและผลขั้นที่ 1 ของนักศึกษาสาขาสังคมศึกษา และสาขาพลศึกษา พบว่ามีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติที่ระดับ .01 แต่ขั้นที่ 2 และ 3 มีความแตกต่างกันอย่างไม่มีนัยสำคัญทางสถิติ

คำสำคัญ: กระบวนการพัฒนา,ทักษะการวิจัย,การคิดเชิงเหตุและผล,เอกสารประกอบการสอนประเภทแบบฝึก

Introduction

The basis of country development is human capital development. Education is the essential process in developing human capital in the aspect of learning skills. An effectiveness of education provision aims to enhance knowledge of learners. The word "knowledge" does not mean only remembering, reciting, or doing things that others or teachers tell to do. The necessary knowledge in developing the learners in cognitive domain include 6 aspects, namely remembering, understanding, applying, analyzing, synthesizing, and evaluating. (Bloom, 1976 cited in SaengThira Charearnnan, 2007: 46).Valuable and important knowledge to be enhanced in learners in all levels is critical thinking. If critical thinking of learners in all levels is developed, the learners will be able to use self-directed learning or learn by themselves. Self-directed learning is a process in which the learner takes the initiative in diagnosing his / her learning needs, formulating goals, identifying human and materials resources, and evaluating learning outcomes. This may be done with or without the help of others. (Knowles, 1975:18). Educators have an important role to play in assisting students to acquire the skills for self-directed learning and to do this they need to understand the concept of self-directed learning. Self-directed learning develops to through information retrieval skills.(Grow,1991:199-226). And, Chaiyos (Chaiyos Paiwithayasiritham, 2014:34) had studied the Factor Analysis of the 21st Century Learning and Innovation Skills of the Teaching Professional Students. The research results revealed that teachers have to find out what the problems or criticisms are and change them to be good opportunities of learning for development and they have to be optimistic or have a positive view in all situations and dare to solve the problems carefully without responding to them with a strong or torrid feeling. Teachers have to find out the way of students' development in any situations.

One of national education standards indicates that learning management must firstly focus on developing learners by applying school based management and student-centered learning process, for students to practice thinking, whereas the Office for National Education Standards and Quality Assessment (Public Organization) or ONESQA determines the thinking standards for learners to have analytical thinking, synthetic thinking, systematic thinking, holistic thinking, critical thinking, reflective thinking, creative thinking, and imagination. In conclusion, government considers the thinking process skill significant.

Thailand's qualification framework for higher education has determined the learning outcome standards that the bachelors are expected to have at least 5 characteristics, namely 1) ethics, 2) knowledge, 3) intelligent skill, 4) interpersonal relationship skill and responsibility, and 5) numerical analysis, communication, and information technology application skills,

especially for intelligent skill, learners are expected to have ability in applying knowledge and understanding on concepts, principles, theories, and various procedures of analytical thinking and problem solving in analyzing the new and unexpected situations.

Thinking is reaction of brain that relates to working process of human mind. The thinking elements, there are planning, organizing relationship system, using old experience for perceiving, and responding by using environment as an assistant, and those are done through the process of analysis, comparison, synthesis, and evaluation in order to get guidelines for solving problems. Thinking can be developed from a simple level in childhood to a complex level in adulthood (Thanyalak Leechuanka, 2001: 9). The ability in logical thinking is ability in critical thinking by using analytical thinking in seeking laws to construct relationship in various forms, to be then diagnosed for conclusion (Chote Petchuen and Ong-art Naipat, 1994: 48).

Critical thinking and Logical thinking are higher order thinking skills. Logical thinking is the interdependent skills of creative thinking, critical thinking, and problem solving. Critical thinking is skills of suspended judgment, logical inquiry, problem solving, evaluative decision or action. (Lewis & Smith, 1993; Carrol, n.d. cited in Goodson & Rohani, 2012:34). So, logical thinking is a thinking skill that is a basis for higher and complex thinking. Critical thinking is logical thinking relating to problem solving. That is, solving problems generally need critical thinking, so logical thinking relates to and can be also used for problem solving.

Teaching process for developing logical thinking can be done in 2 levels, namely 1) the teaching of thinking step by step from simple to complex processes of thinking, i.e. comparison, conclusion, classification, interpretation, and criticism, and 2) the teaching of thinking on problem solving by using 6 types of thinking as a basis which teachers should train the learners to think in sequence, step by step, namely facing problematic situations, identifying the problem, setting hypotheses, anticipating problem solving approaches, expanding and examining hypotheses, testing, and concluding into principles and interpreting into clear meaning. (Kamontip Tortit, 2001: 47-48). An ability in thinking and reasoning is a skill that needs practicing and practicing from various experiences by continuously and properly integrating the practice in teaching normal courses (Guilford & Hoepfner, 1971: 28-32 cited in Pacharin Premprasert, 1999:62)

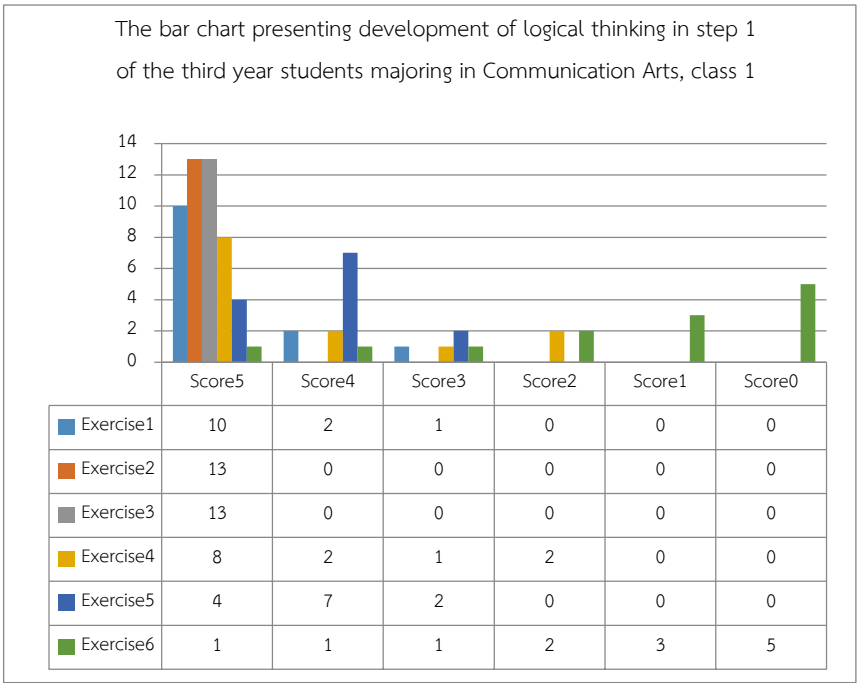
Exercises for skill enhancement help students to practice in contents for more skillfulness (Prathomporn Boonlee, 2002: 43). Exercises are teaching aids for teaching activities that help students learn from doing by themselves, practice their skill in addition to content study until they can perform skillfully, and be able to apply in daily life with teachers' guidance (Tuenjai Treenate, 2001: 5). Moreover, good exercises must be constructed in logical

order from easy to more difficult parts, allow students to practice language usage proper to their ages, culture, tradition, and language background, and act as an exercise for gifted students, and as a remedy for rather slow learners at the same time (Billows, 1962:87). The benefits of exercises consists of 1) enhancement of skill practice, creation of good class atmosphere, and reduction of teachers' workload because of systematic construction of exercises, 2) addition of language skills with teachers' promotion and attention, 3) fulfillment of the gap of individual difference from doing exercises proper to different ability, which helps students achieve more psychological success, 4) retention of language skills, 5) exercises, bound into a book form, useful for students to keep for reviewing lesson by themselves, 6) convenience for teachers to clearly see students' strength and problems, 7) students able to optimize their practice from exercises being constructed in addition to those in textbooks, 8) saving teachers' labor and time in preparing their own new exercises by using exercises already typed or printed, and students' time in copying exercises from textbooks or blackboard ,resulting in having more time for practicing, 9) helping students save cost and systematically and orderly record and see their own progress, and 10) exercises acting as tools for evaluating results of learning after each lesson (Patty, 1968: 469-472 cited in Tuenjai Treenate, 2001: 6). And, Lawrey (Lawrey. 1978:817-A) had studied the results of exercises applied in teaching 87 students in 1-3 levels. The research results revealed that exercises could be used as a tool for helping students learning: the students' scores after doing exercises were higher than those before doing exercises. Besides, exercises could solve the problem of individual difference, so, because of difference in students' language skills, application of exercises could assist students to achieve more success in their learning.

From an experiment on collecting preliminary data of logical thinking in step 1, identification of logical thinking elements of a system, by using 6 sets of exercises, 5 points for each set, the samples were 13 students of third year students majoring in Communication Arts, selected from the students doing all 6 sets of exercises, it was found that the mean scores of exercises 1-6 were 4.69 (93.85%), 5 (100%), 5 (100%), 4.23 (84.62%), 4.15 (83.08%) and 1.46 (29.23%) respectively. The students could get 5 points in exercises 2 and 3 because they were allowed to consult each other. However, the mean scores were likely to be descending, but, when each exercise was considered, it was found that exercises 1, 2, and 3 in which there were logical statements at an easy level, so the students could get 5 points from classifying cause and effect statements, whereas the number of students getting 5 points in exercises 4, 5, and 6 which were constructed for students, by themselves, to give examples of statements with serial contents showing causes, direct effect, and indirect effect, were descending,

especially in exercise 6 there were 5 students getting 0 point, the finding revealed that their logical thinking skill clearly decreased as presented in Figure 1.

Figure1 presents the bar chart of development of logical thinking in step 1 of the third year students majoring in Communication Arts, Faculty of Management Science.



	Score5	Score4	Score3	Score2	Score1	Score0
Exercise1	10	2	1	0	0	0
Exercise2	13	0	0	0	0	0
Exercise3	13	0	0	0	0	0
Exercise4	8	2	1	2	0	0
Exercise5	4	7	2	0	0	0
Exercise6	1	1	1	2	3	5

The conclusion of external evaluation result of education quality assurance system in the third round in the aspect of thinking skills revealed that, in basic educational schools of two secondary schools in Phetchaburi Province, Khao Yoi Wittayakom School and Kongkaram School, were also suggested to improve their students' thinking skills. The former was to improve the students' analytical, synthetic, and critical parallel thinking skills, and brevity in giving opinion, and the students here should be trained to be able to conclude main ideas, to give presentation in front of classroom, and to be the ones who could search for knowledge and learn by themselves, and the latter was also to improve the students' analytical, synthetic, and critical parallel thinking skills. In conclusion, approximately 40% of schools in Phetchaburi Province of which education quality had been evaluated in the third round were suggested to improve the students' thinking skills. (Office for National Education Standards and Quality Assessment (Public Organization), 2013: online).Thus, developing skill of logical thinking or skill of thinking in sequence, step by step, is important to students, especially teacher students, which researchers are interested in developing because these students will be

important manpower for developing education as a powerful factor of Thailand development in the future.

Because of the mentioned findings from preliminary study on essentials of logical thinking, problems in schools found during external evaluation of education quality in the third round in the aspect of logical thinking, Bloom's learning concepts and theories on learning measurement in cognitive domain which must include 6 aspects, namely remembering, understanding, applying, analyzing, synthesizing, and evaluating, and the benefits of exercises, including findings from preliminary study on development of logical thinking of the third year students majoring in Communication Arts which revealed that their logical thinking skill clearly decreased even though it was only development in step 1 in which students were asked to classify cause and effect statements, having not yet done exercises in step 2 and 3 in which thinking skills to be developed were more complex for students to identify direct and indirect effect, the researchers, whose mission was to educate students in various majors, who would in the future be the change agents in social and educational development, got an idea to construct exercises with the great expectation to develop students' research skill in the aspect of logical thinking so that they would gain experience and perception on methodology and logical thinking from the researchers' research process through the process of research project entitled, "A Study on Process for Developing Research Skills of Students at Phetchaburi Rajabhat University in the Aspect of Logical Thinking by Using Exercises as Teaching Materials".

Objective

The objective of this research was to develop research skill in the aspect of logical thinking of students at Phetchaburi Rajabhat University using exercises as teaching materials.

Research Methodology

The 3 steps of research were as follows:

1. Review of basic information for constructing exercises for using as teaching materials, including principles, concepts, and theories on logical thinking was firstly done.

2. Construction of teaching materials in the form of exercises for self-practice and teaching material quality was examined by consulting specialists on thinking process development consisting of 1) Professor Dr. Sumalee Tungpradapkun, Associate Professor Dr. Rattana Makee, and Dr. Sumalee Pongtiyapaiboon. The content validity of exercises as teaching materials was at 1.00.

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3. Experiment of the research tools according to developmental order from step 1 to step 3, was organized continuously in normal classes.

The research samples

The research samples consisted of 197 first year students majoring in Social Studies and Physical Education in Faculty of Education at Phetchaburi Rajabhat University.

The research tool

The teaching materials were constructed base on of self –researchers by application of concepts on compound sentence in Thai language. The form of exercises for self - practice consisted of 12 exercises in 3 elements, according to the steps of construction concepts, were constructed as the follows:

1. Construction of 12 exercises in 3 elements, i.e. 1) identification of logical thinking elements in a system, 2) construction of relationship among logical thinking elements, and 3) application of logical thinking in problem solving.

2. Construction of subjective exercises for students to write their answers in Thai language by themselves, 5 items in each exercise, and 1 point for correct answer of each item for easy interpretation of scores.

3. Application of concepts on compound sentence in Thai language in constructing these exercises by omitting conjunctions in sentences to avoid giving students clues of answers.

4. Determination of topics from students' daily life context to construct short sentences, i.e. using words with clear meanings without modifiers in logical content in each sentence to avoid confusion for students to practice comparison and classification, e.g. "Water is dirty, mosquitoes exist" "selling amphetamine, being sued by police", etc.,

5. Construction of longer sentences with positive meanings by determining a topic with 1 point only, statement with one effect resulting from many causes, for students to create clear mindset of existing effect, e.g. from "Work success depends on teamwork." "Work success depends on responsibility." Into "Work success results from teamwork and responsibility."

6. Construction of exercises that students had to have chances for giving examples of logical sentences to practice applying preliminary knowledge on classifying cause and effect in self-improvement for their learning on higher level of thinking.

7. Construction of exercises from causal statements for students to identify direct effects, and clear indirect results being determined, i.e. exercises with causal statements only and constructors able to initially identify indirect results that students should recognize, which

this exercise construction needed time for thinking about logical statement in order to avoid variation of direct effects and indirect results that may cause arguments on answers.

8. Construction of exercises for students to get thinking process on organizing relationship system and recognize the relationship between causal statements and direct effect, and indirect results, by writing mind map, and using arrow symbols with thick lines and dotted lines to indicate direct effect and indirect results respectively.

9. Construction of exercises from familiar topics and directly relevant to students, i.e. the topic on success in studying, to create thinking for consciousness stimulation, consisting of a number of logical statements that present behaviors relating to persons and their roles or duties for students to identify logical relationship.

10. Construction of exercises from unfamiliar topics by firstly setting the points of direct effect and indirect results, then constructing many longer logical and abstract statements with purpose to create consciousness on being good citizen of the country, for students to develop their thinking in the aspects of comparison, classification, analysis and conclusion of relationship into a figure.

11. Construction of exercises for students to develop their thinking up to the level that they could apply logical thinking in making decision for solving problems on causal conditions, by firstly setting negative effect in only one point and setting causal statement in many points as causes of mentioned effect, to train students to get process of thinking and consideration on making decision in solving problem from various causal statements which were development of thinking on problem solving at a higher level and could be applied in daily life.

The research tool quality

The teaching material quality was examined by consulting specialists on thinking process development consisting of 1) Professor Dr. Sumalee Tungpradapkun, Associate Professor Dr. Rattana Makee, and Dr. Sumalee Pongtiyapaiboon. The content validity of exercises as teaching materials was at 1.00 and reliability was .779 - .827.

Data collection and manipulation:

1. The data were collected from the students studying the courses that were teaching and the students doing all of 12 exercises were purposively selected from their were studying Thai Education and Educational Laws. The teaching materials were used by having students continuously practice in normal classes and using One Shot Case Study Designed.

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2. The data of individual student in each major were filled in the table using excel program.

3. The teaching materials were constructed base on of self – researchers by application of concepts on compound sentence in Thai language and they were easy for undergraduates. The Best' s concept was used to classify the scores. Thus, the scores were interpreted from the students doing exercises in the form of percentage, and classified into X, Y and Z levels. as follows:

S means students majoring in Social Studies

P means students majoring in Physical Education

X means the level of scores at 100% (Excellent)

Y means the level of scores between 50%-99% (Fairy Good)

Z means the level of scores under 50 (Poor)

Data analysis

1. The data were analyzed by using t-test independent for comparing means of the overall result of developing research skill in the aspect of logical thinking in 3 steps of development of the first year students in both majors, Social Studies and Physical Education at Phetchaburi Rajabhat University.

2. The frequency and percentage of students in each major and in each class in 3 steps of development were identified.

Research results

The 2 aspects of research results, results of comparing research skill in the aspect of logical thinking of the students at Phetchaburi Rajabhat University in two majors, Social Studies and Physical Education, and research results of students in each major, were as follows:

1. The research results of comparing research skill in the aspect of logical thinking of the students at Phetchaburi Rajabhat University in both majors, Social Studies and Physical Education were as follows:

Table 1 presents difference testing of means of the overall result of developing research skill in the aspect of logical thinking in 3 steps of the first year students majoring in Social Studies and Physical Education:

Scores	Majors	Means	t	*p*
Step 1	Physical Education	22.44	6.80**	.00
	Social Studies	26.99		
Step 2	Physical Education	16.07	.90	.36
	Social Studies	15.51		
Step 3	Physical Education	9.40	.06	.95
	Social Studies	9.41		

**P<.01 statistical significance at the .01 level

From Table 1, the means of development on research skill in the aspect of logical thinking in the first step of the first year students majoring in Social Studies and Physical Education were overall different with statistical significance at the .01 level, whereas those in the second and third steps were different without statistical significance.

2. The research results of students in each major and class were as follows:

2.1 The number of students, in two majors, whose research skills in the aspect of logical thinking were developed in each step at the levels of X, Y, and Z, were presented in Table 2

Table 2 presents the number of students, in two majors, whose research skills in the aspect of logical thinking were developed in each step at the levels of X,Y and Z:

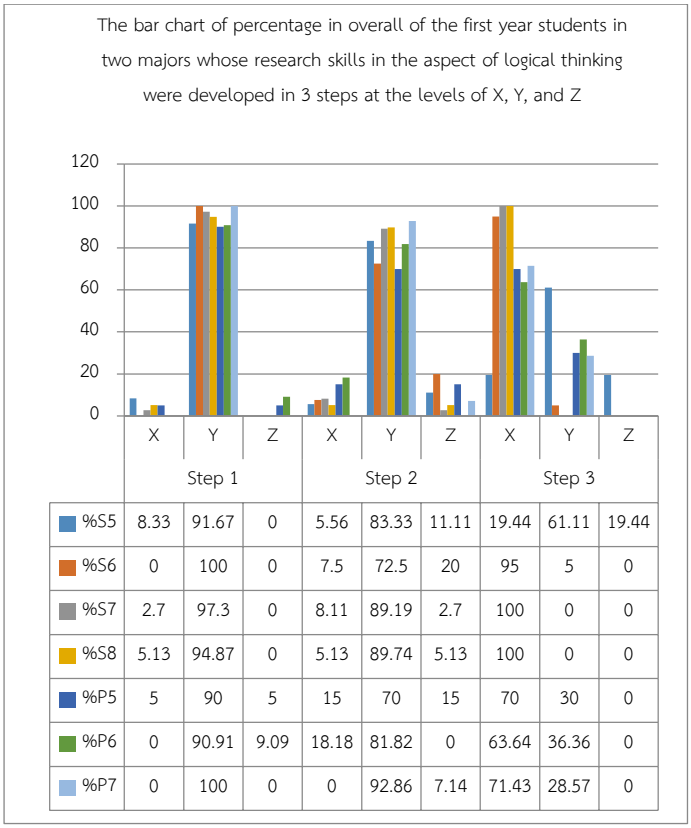
Major/	Step 1			Step 2			Step 3		
Class	X	Y	Z	X	Y	Z	X	Y	Z
S/5	3	33	0	2	30	4	7	22	7
S/6	0	40	0	3	29	8	38	2	0
S/7	1	36	0	3	33	1	37	0	0
S/8	2	37	0	2	35	2	39	0	0
Total	6	146	0	10	127	15	152	24	7
P/5	1	18	1	3	14	3	14	6	0

P/6	0	10	1	2	9	0	7	4	0
P/7	0	14	0	0	13	1	10	4	0
Total	1	42	2	5	36	4	31	14	0

From Table 2, the number of students majoring in Social Studies and Physical Education, whose research skills in the aspect of logical thinking were developed through step1, 2 and 3 with an increasing in level X values from 6 and 1 to 10, 5 and finally to 152 and 31 respectively.

2.2 The percentages in overall and in each major of students whose research skills in the aspect of logical thinking were developed in 3 steps at the levels of X, Y, and Z were presented in Figures 2 and 3 respectively.

Figure 2 presents the bar chart of percentage of students, in two majors, whose research skills in the aspect of logical thinking were developed in each steps at the levels of X, Y, and Z:

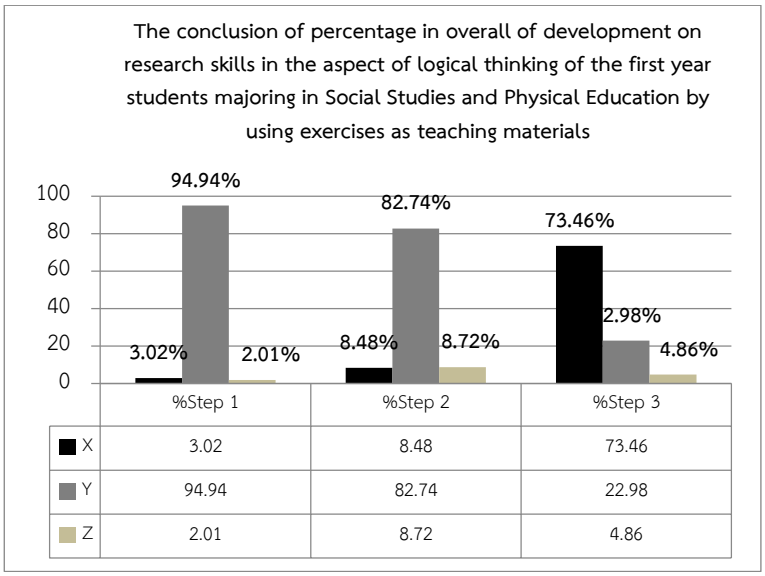


	Step 1			Step 2			Step 3		
	X	Y	Z	X	Y	Z	X	Y	Z
%S5	8.33	91.67	0	5.56	83.33	11.11	19.44	61.11	19.44
%S6	0	100	0	7.5	72.5	20	95	5	0
%S7	2.7	97.3	0	8.11	89.19	2.7	100	0	0
%S8	5.13	94.87	0	5.13	89.74	5.13	100	0	0
%P5	5	90	5	15	70	15	70	30	0
%P6	0	90.91	9.09	18.18	81.82	0	63.64	36.36	0
%P7	0	100	0	0	92.86	7.14	71.43	28.57	0

From Figures 2, the percentage in overall of students majoring in Social Studies and Physical Education, whose research skills in the aspect of logical thinking were developed

through steps1-3, increased at level X, which were 78.61 (100+100+95+19.44/4)and 68.35(70.00+63. 64+71.43/3) respectively.

Figure 3 presents the bar chart of percentage in overall of the first year students in two majors: Social Studies and Physical Education, whose research skills in the aspect of logical thinking were developed in each steps at the levels of X, Y, and Z:



From Figures 3, the percentage in overall of students in both majors, whose research skills in the aspect of logical thinking were developed in steps1-3, were 3.02, 8.48, and 73.46 respectively. When each step of development and each major were considered, it was found that, in the first step of development, most students (94.94%) had logical thinking at level Y, in the second step most students (82.74%) had logical thinking at level Y but the percentages at level X and Z increased, and in the third step most students (73.46%) had logical thinking at level X but the percentages at level Y and Z decreased, especially at level Z there were only 4.86% of students majoring in Social Studies

Discussion

The results of developing research skill of the students in Phetchaburi Rajabhat University in the aspect of logical thinking in steps 1, 2, and 3 by applying exercises as teaching materials could be discussed as the followings:

The comparison of means of logical thinking skill development in step 1: identifying logical thinking elements in a system in 6 exercises, step 2: constructing relationship among

logical thinking elements in 4 exercises, and step 3: applying logical thinking in problem solving in 2 exercises, of the first year students majoring in Social Studies and Physical Education by using t-test revealed that the difference with statistical significance at the .01 level was found in step 1 but the difference without statistical significance was found in steps 2 and 3.

From the research results mentioned above in steps 1, 2, and 3, the students in two majors had got the vividly increasing research skill in the aspect of logical thinking at an X level after being developed through the 3 steps, which the mean scores in step 1 of the students in 2 majors were different with statistical significance at the .01 level. This meant that the two means were not close to each other. When each student's score was considered, it was found that there were 2 students majoring in Physical Education or 4.69% getting the score at a Z level, whereas there was no student majoring in Social Studies getting the score at this level, resulting in less mean score of students majoring in Physical Education than that of students majoring in Social Studies. This resulted from the exercises in step 1 in which the statements were simple, without any modifiers, and were constructed for students to compare words and statements and to classify them into two groups, cause and effect, including sample exercises for students to practice doing before doing by themselves. The researchers constructed those exercises in order to use them for developing the basic thinking skill in the recalling step, the first step of basic thinking, resulting from knowledge accumulation. So, the exercises in step 1: identifying logical thinking elements in a system were as follows: Exercise 1: classifying logical words, Exercise 2: classifying logical statements, Exercise 3: giving examples of causal statements, Exercise 4: giving examples of logical statements, Exercise 5: giving examples of direct and indirect effect of causal statements, and Exercise 6: giving examples of causal statements and direct and indirect effect. And, this resulted from the process of thinking is productive process moves from reflection to inquiry, then to critical though processes that, in turn, lead to a "conclusion that can be substantiated by more than personal beliefs and images".Thinking can straighten out entanglements, clear obscurities, resolve confusion, unify disparities, answer questions, define problems, solve problems, reach goals, guide inferences, shape prediction, form judgments, support decisions, and end controversies. According to Piaget, School-age and adolescent children develop operational thinking and logical and systematic manipulation of symbol. (Goodson and Rohani, 2012:34).

The research skills of students in two majors in the aspect of logical thinking resulting from development in the **second** and third steps were different without statistical significance. This meant that the two mean scores were close to each other. When each student's score was considered, it was found that in the second step most students in two majors had logical

thinking at level Y but the percentages at level X and Z increased, and in the third step the percentage of students in two majors having logical thinking at level X increased but the percentages at level Y and Z decreased, especially at level Z there were only 4.86% of students majoring in Social Studies. **For the result** of thinking development in the second step, constructing relationship among logical thinking elements, the in-depth consideration of research result revealed that the development in the first step through 6 exercises for adjusting all students' thinking process into equal opportunity in the integrated classroom situation helped students have sufficient potential in thinking level for development in the next step, resulting in the highest percentage of students having thinking skill at level Y in the second step, but decreasing from the first step, while it was clearly seen that the percentage of students with thinking skill at level X increased from 3.02 to 8.48 and with thinking skill at level Z from 2.01 to 8.72. The reason why it was so was that the exercises the researchers had constructed for using in the second step were more difficult than those in the first step in order to improve the students' thinking skill to the higher level of thinking, connective thinking, thinking of direct and indirect effect happening from causes, so that the students were ready for improvement in the next step. So, the four exercises in the second step were constructed for students to practice creating relationship among logical thinking elements and be able to conclude into connective concepts of new knowledge in the form of mind map. They were as follows: Exercise 7: constructing mind map of direct and indirect effect from causal statements, Exercise 8: constructing mind map from cause and effect statements on unfamiliar topics, Exercise 9: constructing mind map from cause and effect statements on familiar topics, and Exercise 10: constructing mind map without given statements. **And, this resulted** from critical thinkers are disposed to seek reasons, try to be well informed, use credible sources and mention them, look for alternatives, consider seriously points of view other than their own, withhold judgment when the evidence and reasons are insufficient. (Norris, 1989:22)

For the thinking development in step 3, the in-depth consideration of research result revealed that the percentage of students in two majors with logical thinking at level X increased. It was clearly seen that the percentage of students with thinking skill at level X increased from 8.48 to 73.46 and that with thinking skill at level Z decreased from 8.72 to 4.86**.** This resulted from the exercises in step 3, application of critical thinking in problem solving, in which the 2 exercises being constructed for students to be able to apply their knowledge from the first and second steps in solving problems in daily life were as follows: Exercise 11: identifying problem solving approaches from logical statements, and Exercise 12: applying logical thinking in problem solving. Construction of exercises that students had to have

chances for giving examples of logical sentences to practice applying preliminary knowledge on classifying cause and effect in self-improvement for their learning on higher level of thinking, by firstly setting negative effect in only one point and setting causal statement in many points as causes of mentioned effect, to train students to get process of thinking and consideration on making decision in solving problem from various causal statements which were development of thinking on problem solving at a higher level and could be applied in daily life, they from familiar topics and directly relevant to students, i.e. lack of studying, and then they could apply logical thinking in making decision for problems on causal conditions. And, this resulted from critical thinking is the art of analyzing and evaluating thinking with a view to improving it, self-directed, self-disciplined, self-mentored, self-corrective thinking and effective problem solving abilities. However, excellence in though, must be systematically cultivated. So, a rich intellectual environment is possible only with critical thinking seeks to promote essential for change in education and society.(Paul & Elder, 2007:4).

Conclusion and Recommendations

In conclusion, the research results reveal that 12 exercises the researchers have constructed step by step, consisting of connective elements, for using as teaching materials can improve students' research skill in the aspect of logical thinking. In further application of these exercises, it is recommended that teachers should assign students to continuously do the exercises in order from Exercise 1 to Exercise 12 during studying any courses in normal class and allow each student to have enough chance and time to do exercises without letting the time frame be the limitation of logical thinking skill development. Moreover, every student should be equally and thoroughly developed. The data should be systematically analyzed individually and as a whole to present authentic development level because individual thinking level is not equal, but can be improved. Thus, it is the duty of teachers in universities to develop innovation, including teaching aids, techniques, and approaches, for using in organizing the learning and teaching activities for undergraduate students and students in higher degree to have their thinking skill developed in order to be powerful manpower in the age of deficient educational management when logical thinking skill has been neglected, resulting from focusing on knowledge more than logical thinking skill of education in Thailand.

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