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Effects of Learning Environmental Education Using the Good Science Thinking Moves with Metacognitive Techniques and the Teacher's Handbook Approach on Learning Achievement, Critical Thinking and Basic Science Process Skills of Mathayomsuksa 3 Students with Different Science Learning Achievement

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Abstract: This research aimed to investigate and compare effects of learning environmental education using the good science thinking moves with metacognitive techniques and the teacher's handbook approach on learning achievement, critical thinking and basic science process skills of 90 mathayomsuksa 3 (grade 9) students from 2 classes, selected by the cluster random sampling technique and were assigned to an experimental group and a control group, 90 students each. The instruments for the study included, 6 plans of learning organization using the good science thinking moves with 3 metacognitive techniques: intelligibility, plausibility and wide-applicability for the experimental group and 6 plans of learning organization using the teacher's handbook for the control group, each plan for 3 h of learning in each week; the learning achievement test; the critical thinking test and the test on basic science process skills. The paired t-test and the F-test (Two-way MANCOVA) were employed for testing hypotheses. The substantive findings revealed that the students as a whole and as classified according to science learning achievement showed gains in learning achievement, critical thinking in general and in each subscale and basic science process skills in general and in 6-8 subscales from before learning ($p<0.05$). The experimental group indicated more learning achievement, critical thinking in general and in 2 subscales, basic science process skills in general and in 4 subscales than the control group ($p<0.05$). The high achievers evidenced more learning achievement, critical thinking in general and basic science process skills in general and each 5 subscales more than the low achievers ($p<0.05$). Statistical interactions of science learning achievement and learning model were found to be significant ($p<0.05$) in learning achievement, critical thinking in general and basic science process skills in general and in each subscale.

Key words: Good science thinking moves, metacognitive techniques, critical thinking, basic science process skills

INTRODUCTION

Recently in Thailand, Environmental Education has been cited and conducted in public and private sectors and private development organizations have also involved in this subject. However, situations of environmental problems in Thailand are still in concerned and will become more severe if they are not resolved urgently.

In 1972, the United Nations introduced an idea of environmental education for environmental development by managing learning education for youths in order to build their knowledge and understanding on relationships between components within environment and between human and environment and to create awareness, knowledge, attitude, evaluating competency and participation in solving the environmental problems (UNESCO, 1976s).

The learning education based on a good science thinking moves using metacognitive techniques is a combined techniques of scientific and investigative learning, which is an intellectual process developed by Mittlefehldt and Grotzer (2003). The process consists of 5 steps; connection, questioning, questioning the truth, self-reflection and comparing your idea. Metacognitive techniques comprise intelligibility, wide-applicability and plausibility.

Related papers and researches indicated that learning activities based on the good science thinking approach using metacognitive techniques assisted students in

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transferring knowledge and understanding on events during lesson better than ones who did not learn. Students will mostly use intelligible and wide-applicable metacognitive techniques since the linkage between new ideas and familiar context will help students understand learning's objectives so they can learn efficiently by comparing their ideas with others' ideas. However, a study on learning education using the good science thinking moves with metacognitive techniques on learning achievement, critical thinking and basic science process skills had not yet been investigated. Hence, the researcher determined to study effects of learning environmental education using the good science thinking moves with metacognitive techniques on learning achievement, critical thinking and basic science process skills of Mathayomsuksa 3 students with different science learning achievement. Studied results can be used as information for teachers in science and environmental education classes or as development guidelines for metacognition, learning achievement, critical thinking and basic science process skills in order to efficiently improve environmental quality in the community.

The purposes of this research were therefore:

- To study and compare learning achievement, critical thinking and basic science process skills of students in general before and after experiments and classify science learning achievements according to the good science thinking moves with metacognitive techniques
- To study and compare learning achievement, critical thinking and basic science process skills of students in general before and after experiments and classify science learning achievements according to the teacher's handbook
- To study and compare learning achievement, critical thinking and basic science process skills after experiments of students learning with different learning techniques and science learning achievements

MATERIALS AND METHODS

Research methods and statistical experiment design: Population in this research were 498 Mathayomsuksa 3 students from 10 classrooms studying in the first semester, 2008 academic year, at Chuntarubaksaanusorn School, Roi-Et Educational Service Area Office 2.

A sampling cluster consisted of 90 Matayomsuksa 3 students from 2 classrooms studying in the first semester, 2008 academic year, at Roi-Et Educational Service Area Office 2. The group was drawn by a cluster random sampling technique.

This research was an experimental research that the researcher employed a 2×2 factorial experiment design as a pretest-posttest equivalent groups design (Best, 1997) in a completely randomized design with two fixed effect models; i.e., learning model and science learning achievement.

Instruments using in this research were 6 plans of learning organization in science learning subject group using the good science thinking moves with metacognitive techniques on the experimental group and 6 plans of learning organization using the teacher's handbook on the control group, each plan for 3 h of learning in each week. Four tests were a subtest after each learning organization plan, a learning achievement test, a critical thinking test and a basic science process skills test.

Experiments and data collection: The researcher conducted experiments and collected data as follows:

Teaching preparation: The researcher brought a letter of collaboration from the Graduation Office, Mahasarakham University, to the Director of Chuntarubaksaanusorn School, Amphoe Kasetwisai, Roi-Et Educational Service Area 2, for experiments and data collection.

Classrooms were sampling as experiment and control groups by a drawing method. Mathayomsuksa 3/1 students were drawn to be an experimental group for the learning by the good science thinking moves with metacognitive techniques and Mathayomsuksa 3/2 students were drawn to be a control group for the learning by the teacher's handbook approach.

Each classroom was divided into 2 groups; students with high and low science learning achievements. The groups were determined by transforming scores of Mathayomsuksa 2 science learning subject group into T-Score. Students with high science learning achievements had T-Score equivalent or >50 points and those with low science learning achievements had T-Score <50 points. In the experimental group, there were 29 students with high science learning achievements and 16 students with low science learning achievements. In the control group, there were 20 students with high science learning achievements and 25 students with low science learning achievements.

When, comparing average scores in science learning achievements of the experimental group, the control group and in general, it was found that students with high science learning achievements had higher average scores than students with low science learning achievements ($p<0.05$).

Teaching process: Experiments were conducted by pretesting the experimental and control groups with the learning achievement test, the critical thinking test and the basic science process skills test.

Complete learning organization plans were used as normal classroom timetables for 18 h. During each plan, students took pretest and posttest with subtests as follows:

- Experimental group using the good science thinking moves with metacognitive techniques
- Control group using the teacher's handbook approach

End of teaching process: After specified teaching process was completed, the researcher conducted a posttest on the experimental and control groups using the same version of the learning achievement test, the critical thinking test and the basic science process skills test. Test papers were checked and scores were analyzed by employing statistical methods for hypotheses' testing.

Data processing and analysis: Subtests, learning achievement tests, critical thinking tests and basic science process skills tests were checked and scores were tallied to determine average, percentage and standard deviation.

Post-test scores from learning achievement tests, critical thinking tests and basic science process skills tests were used to test basic assumption of Two-way MANCOVA according to the CRD experiments for normality and homogeneity of variance and homogeneity of covariance matrices. It was found that data conformed to all basic assumption.

Difference between pretest and post-test average scores on critical thinking and learning achievement were tested by employing the Paired t-test.

Scores were analyzed to test hypotheses and two-way MANCOVA on the CRD experiments.

Variable analyzed results with statistical significant were analyzed differences in subscale characteristics by employing the univariate test.

RESULTS AND DISCUSSION

For the experimental group, students as a whole and as classified according to science learning achievement showed gains in learning achievement, critical thinking in general and in 5 subscales and basic science process skills in general and in 6-8 subscales from before learning ($p<0.05$) (Table 1).

Results of this research indicted the followings: the good science thinking learning model is an investigative approach using intellectual procedures (Welch, 1981) that learners cognitive constructions of Social Constructivism (Ernest, 1996) and science process skills as intellectual skills (Finley, 1983), hence students can suitably develop and increase learning achievement, basic science process skills and critical thinking after learning.

On group studying, students practiced 3 metacognitive techniques; intelligibility, plausibility and wide-applicability. Hence, they could reflect their ideas and discuss their friends' ideas so they could suitably develop critical thinking in addition to those skill developments in questioning the learning and self-reflection levels (Mittlefelhdt and Grotzer, 2003).

Students learning by the good science thinking moves with metacognitive techniques had learning achievements after learning in general higher than those learning by the Teacher's handbook models. The critical thinking in general and two subscales, induction and dispute evaluation, of the experimental group were higher than those of the control group ($p<0.05$) and the basic science process skills in general and 4 subscales; i.e., observing, classifying, using space/Relationship and communications of the experimental group were higher than those of the control group ($p<0.05$) (Table 2).

Results of this research indicted the followings: the good science thinking learning model is an investigative approach that emphasizes on cognitive constructions of social constructivism. Students learning in group will practice intellectual skills in each teaching step starting from linking new experience to existing idea, questioning the learning for plausibility, self reflection in the learning, as well as questioning the plausibility of cognitive constructions and comparing one's idea with others' ideas. These activities also use scientific skill so the students always develop their intellectual capability or skill along with a high capability training of critical thinking. Hence, the students can constantly develop better learning achievement, science process skills and critical thinking according to Law of Exercise (Thorndike, 1939) than the students learning by the normal learning model.

Table 1: Comparison of learning achievement, critical thinking and basic science process skills in general of students with different learning models and science learning achievements (Two-way MANCOVA)

Sources of variances	DV	Wilks' lambda	Hypothesis df	Error df	F	p-value
Learning achievement	3	0.476	3.000	84.00	30.844	<0.001*
Learning model		0.272	3.000	84.00	75.046	<0.001*
Learning achievement x learning model		0.618	3.000	84.00	17.332	<0.001*

*Statistical significant level of 0.05

Table 2: Comparison of learning achievement, critical thinking and basic science process skills in general of students with different learning models and science achievements (Univariate tests)

Sources of variances	SS	df	MS	F	p-value
Learning achievement					
Contrast	2592.100	1	2592.100	167.977	>0.001*
Error	1357.956	88	15.431		
Thinking					
Contrast	634.678	1	634.678	31.895	>0.001*
Error	1751.111	88	19.899		
Skills					
Contrast	270.400	1	270.400	12.506	0.001*
Error	1902.756	88	21.622		

*Statistical signification level of 0.017

Table 3: Comparison of learning achievement, critical thinking and basic science process skills in general of students with different learning models and science achievements

Sources of variance	SS	df	MS	F	p-value
Achievement					
Contrast	1264.713	3	421.571	40.634	<0.001*
Error	861.101	83	10.375		
Thinking					
Contrast	292.975	3	97.658	5.182	0.002*
Error	1564.089	83	18.844		
Skills					
Contrast	892.787	3	297.596	24.073	<0.001*
Error	1026.076	83	12.362		

*Statistical significant level of 0.017

Table 4: Comparison of individual basic science process skills after experiments of students with different learning models and learning achievements (Two-way MANCOVA)

Sources of variances	No. of subscales	Hypothesis df	Error df	F	p-value
Science learning achievement	8	8.000	71.000	5.163	0.001*
Learning model		8.000	71.000	5.163	0.001*
Learning achievement x learning model		8.000	71.000	5.163	0.001*

*Statistical significant level of 0.05

All 3 metacognitive moves applied in each learning step as described make the students practice critical thinking properly (Mittlefelhdt and Grotzer, 2003). Besides, critical thinking is an intellectual capability contributing to promote development of science process skill, which is also an intellectual capability. Accordingly, development of these capabilities by the good science thinking moves will be more suitable and better than development by the normal learning model.

The students with high science learning achievements showed higher gains than the students with low science learning achievements in learning achievement, critical thinking in general and basic science process skills in general and all subscales ($p<0.05$) (Table 3).

Reasons for the students with high science learning achievements after the investigative learning having higher gains than the students with low science learning achievements in learning achievement, critical thinking in general and basic science process skills may come from: the students with high science learning achievements have more and better mental structure (Piaget, 1974) and knowledge structure (Ausubel, 1968) than those with low science learning achievements so they can learn about intangible subjects and develop intellectual capability in science process skills and critical thinking better than others. The students with high science learning achievements have more achievement motivation (Atkinson, 2006) and self-confidence (Jakobsson, 2006) than those with low science learning achievements. Since they always succeed in learning as expected, therefore, they will pay more attention and eager to learn more resulting in better learning achievements in all 3 subscales.

Statistical interactions of science learning achievement and learning model were found to be significant ($p<0.05$) in learning achievement, critical thinking in general and basic science process skills in general and in 5 subscales (Table 4).

The interaction of science learning achievement and learning model affects the preparation of science teaching suitable for student groups with different characteristics, so students will have self confidence in learning, achievement motivation and eagerness in learning until they can fully a potentiality develop their learning achievement, science process skills and critical thinking.

CONCLUSION

In this research, the researcher presented 5 research results as follows: the students in the experimental group as a whole and as classified according to science learning achievement showed gains in learning achievement, critical thinking in general and in 5 subscales and basic science process skills in general and in 6-8 subscales from before learning ($p<0.05$).

The students in the control group as a whole and as classified according to science learning achievement showed gains in learning achievement, critical thinking in general and in 5 subscales and basic science process skills in general and in 4-8 subscales from before learning ($p<0.05$).

The students in the experimental group showed higher gains than the students in the control group in learning achievement, critical thinking in general and in 2 subscales, deduction and evaluation of arguments and basic science process skills in general and 4 subscales; i.e., observing, classifying, using space/Relationship and communications ($p<0.05$).

The students with high science learning achievements showed higher gains than the students with low science learning achievements in learning achievement, critical thinking in general and basic science process skills in general and 5 subscales; i.e., observing, classifying, using space/Relationship, communications and inferring ($p<0.05$).

Statistical interactions of science learning achievement and learning model were found to be significant ($p<0.05$) in learning achievement, critical thinking in general and basic science process skills in general and in 5 subscales; i.e., observing, classifying, using space/Relationship, communications and using numbers ($p<0.05$).

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