

Full Length Research Paper

Development of knowledge, awareness, global warming decreasing behavior and critical thinking of grade 11 students using the Four Noble Truths method with meta-cognitive techniques

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This study aims to investigate the effects of learning environmental education on the knowledge, awareness, global warming decreasing behavior, and critical thinking of eighty grade 11 students from two classes. The Four Noble Truths method with metacognitive techniques and traditional teaching method were used for the investigation. The sample was obtained by using cluster random sampling techniques. The Four Noble Truths method with metacognitive techniques was used for forty students that made up the experimental group while the traditional learning method was used for the control group consisting of forty students. The research instruments included five- lesson plans using the Four Noble Truths method with three metacognitive techniques : intelligibility, plausibility and wide-applicability (each plan consists of three hours learning per week); a knowledge test on global warming ; questionnaire on global warming awareness; questionnaire on global warming decreasing behavior; and a critical thinking test. The major findings revealed that the experimental group and based on prior Biology learning outcome had more knowledge, awareness, global warming decreasing behavior, and critical thinking prior to learning. The high Biology achievers had higher awareness of global warming in two areas, global warming decreasing behavior in one area and critical thinking than the lower Biology achievers in three areas. The experimental group had more knowledge, awareness of global warming generally and in one area, global warming decreasing behavior generally and in one area and overall critical thinking in three aspects than the control group students. In addition, there were statistical correlations between prior Biology learning outcome with learning model and global warming awareness, global warming decreasing behavior, and critical thinking.

Key words: The Four Noble Truths method, metacognitive techniques, global warming, awareness, critical thinking

INTRODUCTION

Nowadays, welfare and economic growth along with excessive use of natural resources has become a

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dominant issue in many countries across the globe. About 70% of natural disasters currently occurring are the result of climate changes, and it seems that this trend is increasing (Preston et al., 2008). Studies have shown that despite international attempts to reduce the effects of global warming, the emission of greenhouse gases is trending up. This is because the emission increase rate from developing countries is greater than that of developed countries. It is predicted that this condition will become more critical in future (UNDP, 2008). Global warming occurs mostly by burning fossil fuels such as petroleum, coal and natural gases (WMO, 2013). The greenhouse gases (carbon dioxide, methane, nitrous oxide, chlorofluoro carbon) can prevent the release of heat from the earth surface into space by adsorbing infrared radiation. This increases the world temperature (UNESCO and UNDP, 2011a). This phenomenon can have consequent impacts on environments such as an increase of sea water level due to the melting glaciers in the world polar zone (UNESCO and UNEP, 2011b), drought, lack of water, desert expansion, and severe weather conditions (heavy rain, floods, and cyclones) (Leighton, 2011). Increased temperature causes the outbreak of malaria and diarrhea. In Thailand, the Ministry of Education emphasizes that education is the essential way for sustainable development and integrating the fusion of environmental education into the whole process of education at primary and secondary levels. Environmental education develops learners' knowledge, attitude awareness, skills, and participation in solving environmental problems (Winscons in Department of Public Instruction, 1999). In other words, environmental education can raise environmental awareness, promote sustainable development, improve the capacity of people to address environment and development issues and generate effective action (Simon, 2000). In an organization of teaching and learning, the teacher can use various teaching methods to manage an environmental education depending upon the contents and learners. In this research, the researcher is interested in the Four Noble Truths (FNT) method developed by Saroj Boasri (The Institute of Culture and Arts, 2010). The method applies the Buddhist principles for instruction with systematic thinking procedures comparable to the scientific method. The FNT method has four stages: suffering, cause of suffering, cessation of suffering, the way to the cessation of suffering which emphasizes problem solving by oneself (Four Noble Truths, 2014 : website). This method can be applied to instruction for solving global warming and degradation of environments caused by human activities.

Wiriyasitaporn (2011)'s research findings on teaching and learning using the FNT method revealed that the students that learned with the FNT method had higher learning achievement prior to learning, higher learning achievement than the students that learned with the

traditional learning method (Mhodsiri, 2011), higher critical thinking prior to learning (Kingkaew, 2013), and higher critical thinking than the students who used the teacher manual method to learn (Sakjirapapong, 2008).

An effective teaching and learning can develop higher-order thinking of students by giving them practical activities to do by themselves. One of the higher-order thinking which can be developed and practiced is metacognition. Metacognition is very important in building a meaningful learning by using planning, monitoring and evaluation. It is a process of learning and solving problem. Previous research findings showed that the students who learned with metacognitive techniques had higher intelligibility, plausibility and wide-applicability; could transfer knowledge and understanding about inter-lesson situations better than the students who learned without metacognitive techniques (Mittlefehldt and Grotzer, 2003). The students who used meta-cognitive techniques had more learning achievement (Appamaraka et al., 2009), more consciousness of environmental conservation and development (Sihapong, 2009), more environmental conservation behaviors (Rukkhachet, 2012), and higher critical thinking than the students using the teacher manual method (Jattuchai, 2010).

Based on related documents and research findings, the researcher is interested in comparing the effects of management of teaching and learning environmental education on global warming knowledge, global warming awareness, global warming decreasing behaviors, as well as critical thinking of grade 11 students, using the FNT method with meta-cognitive techniques and traditional teaching method.

Meta-cognitive techniques

The inquiry here is formed by three categories of metacognitive techniques for teaching, adapted from Beeth (1989a). These categories are meant to help students use metacognition in order to develop their critical thinking. The first category is intelligibility which encompasses how students reflect abstractly on the content of their thinking. That is, when students ask themselves, "Does this make sense to me?" It is useful because it gives students a conceptual foundation to activate their metacognitive processes. When assessing the intelligibility of a new idea, students may reflect on other students' ideas, or the teachers' ideas. They may ask themselves, "How does the way that this person thinks about the idea help me make sense of it?"

The second category "plausibility" enables students to test their faith in a particular idea. It is the realm in which students negotiate the status of their ideas. It encompasses the type of metacognition that occurs when students ask themselves, "Should I really believe this idea?" When testing the plausibility of an idea, students may seek

counter-evidence against an idea. As a result, the students are often very self-aware of their learning and skeptical of ideas that they only partially understand.

The third category is “wide-applicability”. Employing this technique, students apply what they know about their thinking from one context to another. It involves connection making and looks at the role of reflection through experience. Students may ask themselves, “How can this concept help me in other areas of my learning? Or “What experience (in class or outside of class) have I had that would help me to make sense of this idea?” “Wide-applicability” is the metacognitive tool that a student might use to transfer his/her knowledge, belief, or thinking from one context to another. It is an important category of transfer.

The metacognitive techniques could work both on intra-personal as well as interpersonal level, as shown in Table 1 (Mittlefehldt and Grotzer, 2003).

The research objectives

1. To study and compare the knowledge, awareness, global warming decreasing behaviors, and critical thinking before and after learning using the Four Noble Truths method with metacognitive techniques of grade 11 student as a whole and as classified according to prior biology outcome and learning model.
2. To study and compare knowledge, awareness, global warming decreasing behavior and critical thinking of the students with different prior biology learning outcomes and learning models, after learning.

RESEARCH METHODOLOGY

Population and sample

The population consists of two hundred and fifteen grade 11 students from six classes with heterogeneous ability, in the second semester of the 2013 academic year. They attend Nadoon Prachasan School under the Office of Secondary Education Service Area, Zone 26 in Nadoon sub-district, Nadoon District, Maha Sarakam Province, Thailand.

The sample consists of eighty grade 11 students from two classes (forty students each), in the second semester of the academic year 2013. They attend Nadoon Prachasan School. They were selected with cluster random sampling techniques; a class was used as a sampling unit.

Study variables

Independent variables

They include the learning model with two methods: the FNT with metacognitive techniques and the traditional teaching method, as well as the prior biology learning outcome, which consists of high Biology achievers (T-score ≥ 50) and low Biology achievers (T-score < 50).

Dependent variables

They consist of knowledge, awareness, global warming decreasing behavior, and critical thinking.

Instrument

The instruments used for the study include lesson plans, a test on global warming knowledge, questionnaire on global warming awareness, questionnaire on global warming decreasing behavior, and critical thinking test. Detailed information about the instruments is given as follows.

Lesson plans on environmental education entitled, *Global warming* entail using the FNT method with three metacognitive techniques (intelligibility, plausibility, and wide-applicability) for the experimental group students and the traditional teaching method for the control group students; they are 5 plans consisting of 3 h learning in a week.

With respect to the development of the FNT lesson plans, some metacognitive techniques or questions were added to each stage of the method; for instance, adding intelligibility and plausibility to the first stage, adding intelligibility, plausibility and wide-applicability to the fourth stage.

The researcher constructed a multiple-choice test on global warming with 40 items: difficulties (p) ranged between 0.21 and 0.79, discriminating values (r) between 0.20 and 0.61, and a reliability of 0.913.

The rating-scale questionnaire on global warming awareness has 30 items: discriminating values ranged between 0.29 and 0.72, and a reliability of 0.927.

The rating-scale questionnaire on global warming decreasing behavior has 30 items: discriminating values ranged between 0.21 and 0.66, and a reliability of 0.918.

The critical thinking test based on the Cornell Critical Thinking level X, constructed by Ennis and Millman (1985), has 4 alternatives and 40 items. The test contained 4 areas: credibility of sources and observations, deduction, induction, and assumption identification, with discriminating values ranging between 0.21 and 0.50 and a reliability of 0.831.

Data collection

There are three stages of data collection as follows.

Preparation

The two selected classes of grade 11 students were randomly assigned to experimental and control groups. Each group of the students was divided into high Biology achievers and low Biology achievers based on the T-score.

Teaching and learning

The global warming knowledge test, questionnaire on global warming awareness, questionnaire on global warming decreasing behavior and critical thinking test were administered to the two groups of students prior to the start of the teaching and learning period. The two groups were taught by the researcher who used the 5 assigned lesson plans for three weeks, 3 h each.

Table 1. Metacognitive techniques: context and characteristic questions.

Metacognitive techniques	Context	Characteristic questions
Intelligibility	Intra-personal	Does this idea make sense to me ? What part of this idea make sense to me? What do I find difficult about this idea?
	Interpersonal	What part of Jany's model makes sense to me? What might I add to have it make sense to me?
Plausibility	Intra-personal	Should I believe this idea? Does this idea seem likely to be true?
	Interpersonal	Should I believe this Jany's model? Even if it makes sense to me; is there something about it that seems unlikely to be true? What is believable about it?
Wide-applicability	Intra-personal	How can this idea help me in other areas of my learning? Are pieces of this ideas that relate to other ideas I learned about? What are the fundamental ways in which they relate?
	Interpersonal	How does Jany's model help me think about other ideas we've talked about?

Evaluation

After the end of the teaching and learning activities, the two groups were tested by using the 3 pretest instruments as an immediate posttest. Only the questionnaire on global warming decreasing behaviors was administered to the two groups in a four-week period after the termination of the learning as a delayed posttest.

Data analysis

All of the collected data from the pretest and posttest instruments were analyzed as follows.

The pretest and posttest scores of the four instruments were analyzed to test assumptions of the Two-way MANCOVA and ANCOVA in terms of normality, correlation of dependent variables, homogeneity of variance, homogeneity of regression slope, and homogeneity of variance-covariance matrices. The tested results confirmed the assumptions at the .05 level of significance.

The scores from 5.1 were tested for the difference between the pretest and posttest measures using the paired t-test according to the whole students, the high Biology achievers and the low Biology achievers of each group.

The posttest scores from 5.1 were analyzed for testing the hypothesis that the students with different prior biology outcomes and learning models had different knowledge, awareness, behavior, and critical thinking, using the F-test (Two-way MANCOVA and ANCOVA).

FINDINGS

The research findings are presented as follows.

- 1) The whole students, the high Biology achievers and the low Biology achievers in the experimental and control groups had higher global warming knowledge, global warming awareness, global warming decreasing behavior and critical thinking prior to learning ($p < .001$).
- 2) The high Biology achievers had more global warming awareness generally and in two areas (awareness of global warming impact and global warming prevention);

higher global warming decreasing behavior generally and in five areas; and higher critical thinking generally and in three areas, except for assumption identification than the low Biology achievers ($p \leq .007$) (Tables 2-5). However, the two groups did not have global warming knowledge differently.

3) The experimental group students had more global warming knowledge, global warming awareness generally and in one area; higher global warming decreasing behavior generally and in an area; and higher critical thinking in three aspects, except for the deduction aspect, than the control group students ($p \leq .002$) (Tables 2-5).

4) Statistical interactions between prior Biology learning outcome with learning model and global warming awareness generally and in two aspects: cause of global warming and global warming prevention; global warming decreasing behavior generally and in four aspects: except for the travel behavior aspect; and an entire critical thinking were found to be significant ($p \leq .039$) (Tables 2-5).

DISCUSSION

This study illustrates the positive influences of the FNT method with metacognitive techniques on knowledge, awareness, behavior and critical thinking of the students. Some discussions are presented in details as follows.

Firstly, the students who learned with the FNT method with metacognitive techniques had higher gains in their four learning outcomes prior to learning; this is supported by research findings of Wiriyasitaporn (1991) that the students who learned using the FNT method had more learning achievement and critical thinking (Bowonchakpop, 2011) prior to learning. This might be due to the fact that FNT method is one of the learner-centered learning experiences which provide opportunities for students to learn by doing and thinking and participating in learning

Table 2. Comparison of global warming knowledge, global warming awareness, global warming decreasing behavior and critical thinking of grade 11 students with different prior biology learning outcomes and learning models (Two-way MANCOVA).

Source of variance	Statistical test	F	Hypothesis df	Error df	p	Partial Eta squared
Pretest knowledge	Wilks' Lambda	3.558	4.000	69.000	.011*	.171
Pretest awareness	Wilks' Lambda	3.855	4.000	69.000	.007*	.183
Pretest behavior	Wilks' Lambda	1.662	4.000	69.000	.169	.088
Pretest critical thinking	Wilks' Lambda	3.187	4.000	69.000	.018*	.156
Biology learning outcome	Wilks' Lambda	20.084	4.000	69.000	<.001*	.538
Learning model	Wilks' Lambda	66.709	4.000	69.000	<.001*	.795
Interaction	Wilks' Lambda	4.107	4.000	69.000	.005*	.192

*significant at the .05 level.

Table 3. Comparison of global warming awareness in each aspect of grade 11 students with different prior biology learning outcomes and learning models(Two-way ANCOVA).

Awareness	Source of variance	SS	df	MS	F	P	Partial Eta Squared
Causes of global warming	Pretest	5.751	1	5.751	46.964	.000*	.385
	Learning outcome	.121	1	.121	.987	.324	.013
	Learning model	1.996	1	1.996	16.296	<.001*	.178
	Interaction	.539	1	.539	4.406	.039*	.055
	Error	9.184	75	9.184			
Impact of global warming	Pretest	.060	1	.060	.603	.440	.008
	Learning outcome	1.040	1	1.040	10.405	.002*	.122
	Learning model	9.374	1	9.374	93.756	<.001*	.556
	Interaction	.008	1	.008	.079	.779	.001
	Error	7.499	75	.100			
Global warming prevention	Pretest	3.550	1	3.550	30.706	.000*	.290
	Learning outcome	3.824	1	3.824	33.069	<.001*	.306
	Learning model	16.003	1	16.003	138.401	<.001*	.649
	Interaction	3.691	1	3.691	31.923	<.001*	.299
	Error	8.672	75	.116			

*significant at the .05 level.

activities through four stages: suffering (setting problem), cause of suffering (formulating hypothesis), cessation of suffering (experimenting/collecting data), and the way leading to cessation of suffering (discussing/concluding). The students received direct experiences from doing by themselves through searching data, processing data, drawing conclusion and using their own learning method. This is supported by the Bruner's learning theory that emphasizes learning from experience or doing and reasoning (thinking) (Bruner, 1966). In addition, the students made use of the metacognitive techniques (intelligibility, plausibility, and wide-applicability), which facilitate the construction of knowledge or idea of the students and group member during a small group

working session (a type of co-operative learning) (Johnson and Johnson, 1991). The students, therefore, could collaboratively think and conclude on the knowledge gained from learning, which is supported by the social constructivist views (Suksringarm, 2007). The students had adequate knowledge which facilitated awareness and finally led to changes in behavior (Schwartz, 1974).

Secondly, the high Biology achievers had more global warming awareness generally and in two aspects (awareness of global warming impacts and global warming prevention (Table 3); global warming decreasing behavior generally and in all five aspects (Table 4) and the critical thinking generally and in three aspects, except

Table 4. Comparison of global warming decreasing behavior in each aspect of grade 11 students with different prior biology learning outcomes and learning models (Two-way ANCOVA).

Behavior	Source of variance	SS	df	MS	F	P	Partial Eta Squared
Consumption behavior	Pretest	.031	1	.031	.178	.674	.002
	Learning outcome	1.148	1	1.148	6.569	.012*	.081
	Learning model	3.373	1	3.373	19.304	.001*	.205
	Interaction	.967	1	.967	5.533	.012*	.069
	Error	13.106	75	.175			
Energy conservation behavior	Pretest	1.557	1	1.557	5.011	.028*	-.63
	Learning outcome	4.072	1	4.072	13.101	.001*	.149
	Learning model	4.772	1	4.772	15.352	.001*	.170
	Interaction	3.824	1	3.824	12.301	.001*	.141
	Error	23.312	75	.311			
Waste disposal behavior	Pretest	.918	1	.918	6.204	.015*	.076
	Learning outcome	2.566	1	2.566	29.087	.001*	.279
	Learning model	3.476	1	3.476	20.986	.001*	.219
	Interaction	.524	1	.524	5.063	.027*	.063
	Error	9.566	75	.128			
Travel behavior	Pretest	.832	1	.832	2.649	.108	.036
	Learning outcome	1.562	1	1.562	4.974	.029*	.065
	Learning model	4.002	1	4.002	12.747	.001*	.161
	Interaction	8.60	1	8.60	2.738	.102	.039
	Error	23.549	75	.134			
Global warming and supporting behavior	Pretest	2.100	1	2.100	4.451	.038*	.056
	Learning outcome	5.319	1	5.319	10.765	.002*	.126
	Learning model	5.886	1	5.886	11.914	.001*	.137
	Interaction	4.091	1	4.091	8.281	.005*	.099
	Error	37.005	75	.494			

*significant at the .05 level.

for assumption identification (Table 5) than the low Biology achievers. This might be due to the high confidence of the high Biology achievers in their abilities to learn (Jokobson, 2006), being more self-directed learning behavior (Heins, 1980), and having more achievement motivation than the low Biology achievers. These characteristics could help the high Biology achievers respond to each learning activity at a more frequent level. They could develop more awareness, which led to change in the global warming decreasing behavior. Also, all experiences they received from this type of teaching and learning might facilitate the development of their critical thinking abilities.

Finally, the students who learned using the FNT method with metacognitive techniques or metacognition-typed questions had more knowledge, awareness in general and each aspect, global warming decreasing

behavior generally and in an aspect and critical thinking generally and in three aspects, except for the deduction aspect more than the students who learned using the traditional teaching method. This is supported by some research findings that the students who learned using the FNT method had more learning achievement (Mhodsiri, 2013), and critical thinking (Sakjirapapong, 2008) than the students who learned using the traditional teaching method. This might be due to the fact that FNT method with metacognitive techniques is a type of learner-centered activity, which emphasizes learning by experience and thinking, based on Bruner's view (Bruner, 1966). The students also employed the metacognitive techniques to monitor themselves in accomplishing their learning and developing their critical thinking abilities. Furthermore, a small learning and discussion group can help their co-operative learning and construct a

Table 5. Comparison of critical thinking in each aspect of grade 11 students with different prior biology learning outcomes and learning models (Two-way ANCOVA).

Critical thinking	Source of variance	SS	df	MS	F	P	Partial Eta Squared
Credibility of sources and observations	Pretest	8.216	1	8.216	5.814	.018*	.072
	Learning outcome	20.860	1	20.860	14.762	<.001*	.164
	Learning model	92.156	1	92.156	65.214	<.001*	.465
	Interaction	5.142	1	5.142	3.638	.060	.046
	Error	105.985	75				
Deduction	Pretest	35.938	1	35.938	26.562	.001*	.262
	Learning outcome	21.922	1	21.922	16.202	.001*	.178
	Learning model	.006	1	.006	.004	.948	.000
	Interaction	.794	1	.794	.587	.448	.008
	Error	101.474	75	1.353			
Induction	Pretest	2.811	1	2.811	1.409	.239	.018
	Learning outcome	11.159	1	11.159	5.594	.012*	.069
	Learning model	42.527	1	42.527	21.318	.001*	.221
	Interaction	3.643	1	3.643	1.826	.181	.024
	Error	149.619	75	1.995			
Assumption identification	Pretest	12.017	1	12.017	8.298	.005*	.100
	Learning outcome	1.905	1	1.905	1.218	.273	.016
	Learning model	114.613	1	114.61	73.316	.001*	.494
	Interaction	.916	1	3	.586	.446	.008
	Error	117.247	75	.916			

*significant at the .05 level.

knowledge group, based on the social constructivist view (Suksringarm, 2007). The students with more knowledge of global warming might have an adequate awareness leading to global warming decreasing behavior (Schwartz, 1974) more than those students who learned using the traditional teaching method.

RECOMMENDATION

The Four Noble Truths method with metacognitive techniques is an effective teaching and learning method for enhancing knowledge, awareness, global warming decreasing behavior and critical thinking of the students. This method is based on learner-centered activities and the view of learning by experience and thinking, the social constructivist view and intellectual procedures of metacognitive techniques. The teachers, therefore, should be encouraged and supported to implement this method in teaching environmental education at any grade level.

Conflict of Interests

The authors have not declared any conflict of interests.

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