

## **Promotion of scientific literacy on global warming by process drama**

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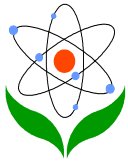
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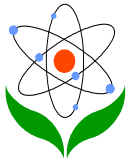
## Abstract

This project aims to investigate how process drama promotes scientific literacy in the context of global warming. Thirty-one lower ( $n = 24$ ) and upper ( $n = 7$ ) secondary students of one secondary school in Bangkok, Thailand participated in a seven-day workshop which process drama strategy was implemented. In the workshop, the students were actively engaged in a series of lab exercises, critically reviewed global warming issue presented in selected printed media, and watched a documentary film to understand the science, conflict, and solutions of the global warming. In addition, the students were trained on acting, elements of drama, and storytelling. They made and selected a story, developed a script, formed casts and production crews and performed the drama to the public. Data were collected by using a questionnaire, participant observation, informal interviews, student daily journals, and drama scripts. Results showed that the students developed scientific perception of the keywords related to global warming and conceptual understanding of the causes, processes, and consequences of global warming after the workshop. Students' views on the solution of global warming were integrated, creative and critical. The students increases intensity in engagement in solving global warming.

**Keywords:** Process drama, global warming, scientific literacy, Thailand

## Introduction

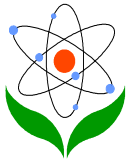
The 15th United Nations Climate change conference or COP15 was held at Bella Center in Copenhagen, Denmark in December, 2009 (Birch, 2010). It was the largest international political conference so far on global warming with participants from 192 countries representing governments, the business community, and civil society. Since the consequences of global warming have been extraordinary, the world community needs to take serious action on reducing greenhouse gas emission, a cause of global warming, and creating a low carbon economy and society. COP15 provided a common ground for a coherent global response to this challenge and facilitated the process of reaching agreement on win-win situation basis. COP15 perfectly reflects the complexity and difficulty of the issue of global warming. Taking a decision regarding global warming requires scientifically literate individuals who understand the implications of their actions and have the skills to critically think about environmental issues and make informed and responsible decisions.



In Thailand, global warming has become a hotly debated issue and a large concern at the national level. Thailand has been experiencing the consequences of global warming (McDonald-Gibson, 2007) such as flash floods in northern areas of Thailand, the rise in level of the Andaman Sea, the decline in the annual flow of the Mekong River, the decrease in agricultural production etc. In September 2007, Assumption University conducted a poll of 2,191 people aged above 18 in Bangkok and surrounding areas which showed that global warming worried 97% of all respondents (Thai News Agency, 2007).

In this respect, to respond to national and international call on solving global warming, Thailand has established goals leading to the reduction of greenhouse gas emissions. Thailand signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the Kyoto Protocol in 1999 (Intergovernmental Panel on Climate Change, 2001; Schelling, 2007). Consequently, it prepared and has implemented measures to reduce greenhouse gas emissions which include regulations, fiscal incentives, information, research and development. The Thai Ministry of Education decided to include global warming and climate change in the National Curriculum Framework with the aim of informing students about its scientific background and the complexity of the issue and empowering them to make positive contributions to this issue (Institute for the Promotion of Teaching Science and Technology, 2002).

Science educators have sought to teach the fundamentals and complexity of global warming to a school audience in Thailand. However, teaching global warming is problematic for two main reasons. First, previous studies suggested that student's ideas about global warming were commonly alternative to those accepted in a community of practicing scientists and this was found to be true across different countries even after formal instruction (Francis et al., 1993; Rye, Rubba, & Wiesenmayer, 1997; Gautier, Deutsch, & Rebich, 2006; Lee et al., 2007; Kiliç, Stanisstreet, & Boyes, 2008). Students' ideas are robust and persistent into adulthood despite formal teaching (Driver, Squires, Rushworth, & Wood-Robinson, 1994). Second, global warming is complicated since there are a number of parties involved with a variety of needs, values and interests. Scientific knowledge and positive attitude toward the environment might not be enough. It is not necessarily true that a high level of environmental knowledge correlates with a higher degree of environmental concern, willingness to make personal sacrifices and environmentally responsible behavior. The students might still make reckless



environmental decisions and actions regardless of their scientific conceptions (Kuhlemeier, Bergh, & Lagerweij, 1999). Critical thinking, management, and conflict resolution skills, therefore, are needed to succeed in solving the global warming. The traditional style of science teaching, in which teachers rely solely on chalk and talk or conducting scientific investigation is ineffective in this case (Mason & Santi, 1998).

To enhance scientific literacy on global warming, it is advisable for science teachers to create opportunities which will enable students to interact with the world and to understand it more fully through that interaction so they may function more successfully in it (Taber & Taylor, 2009). Environmental education should be humanized. In humanistic science education, feelings, fantasies, and values are combined with thinking and knowing. (Bruner, 1986; Appleby, 2002). The students should be nurtured to become future decision makers; understand how changes in the environment will affect them; and how they can become involved in the issues and decisions that will ultimately affect them (AAAS, 1993; Landers, Naylor, & Drewes, 2002).

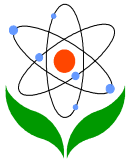
In this project, process drama is introduced and examined its effectiveness in promoting scientific literacy on global warming. This learning process has the potential to cultivate scientific literacy on global warming by a several reasons. Process drama is an inquiry-based teaching method in humanistic paradigm. It provides a framework for the exploration of ideas and feelings and the making of meaning. It is also a social, interactive and empowering arts process. It sharpens perception, enables personal expression, imagination and aesthetic sensitivity. Therefore, it can create experiences which enable the development of cognitive, emotional, social, and creative understanding and skills (Erickson, 1988; Bailey, 1993; Wood, 2006).

## **Purpose of the Study**

The purpose of this study is to investigate the role of process drama in the promotion of scientific literacy in the context of global warming.

## **Theoretical Frameworks**

This review is written to highlight specific arguments and ideas about process drama for developing scientific literacy. It provides an overview of issue or theories



under consideration in this study; reviews the critical points of current knowledge of variables related to the research topic covering scientific literacy, process drama, humanistic science education and scientific background of global warming.

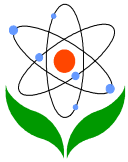
## **1. Scientific literacy**

Scientific literacy is defined as the knowledge, understanding, and skills required for personal decision making, participation in civic and cultural affairs, and economic productivity in a world shaped by science and technology (American Association for the Advancement of Science, 1993; National Research Council, 1996). The scientifically literate person is, therefore, characterized as a person who is able to comprehend scientific issues in magazines, newspapers and other media; evaluate the quality of scientific information on the basis of its source, the methods used to generate it, the arguments based on evidence; and to apply conclusions from such arguments appropriately. He or she, in addition, can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed that often involve evidence, quantitative considerations, logical arguments, and uncertainty. Based on literature review, in this study, scientific literacy consists of two elements, conceptual understanding of and engagement in a socio-scientific issue.

Conceptual understanding is the explanation about natural phenomena. It is meaningful for that person. It is an everyday mode of talking and thinking about the phenomenon which is logical, coherent and internally consistent. It may be different the scientific view. Children's ideas were found robust and persist into adulthood despite formal teaching. Basic steps for conceptual change are suggested; revealing student preconceptions, discussing and evaluating preconception, creating conceptual conflict with those preconceptions, and encouraging and guiding conceptual restructuring (Duit, 1999).

Engagement is the meaningful and sustained involvement of people in an activity. The students engaged in action to tackle an environmental problem when they are actively and authentically involved, motivated, and excited about an environmental issue, process, event or program (Hungerford & Volk, 1990).

Roger Hart (1992) proposed Ladder of Participation, a model of intensity of engagement in environmental education from non-participation to youth assigned and informed; to youth consulted and informed; to adult-initiated, to share decision



with youth; to youth and adults share decision-making; and to youth lead and initiate action.

## **2. Humanistic science education**

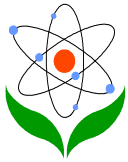
Humanistic science education is the education for world citizenship. It develops moral reasoning integrated with values, human concerns, and scientific reasoning. It also promote personal fulfillment, self-actualization, interpersonal relations, experiential learning. This kind of science education employs induction, socialization, or enculturation into students' local, national, and global communities that are increasingly shaped by science and technology. Humanistic science education focuses on the development of the whole and sees cognition as inseparable from affect. It addresses physical development/kinesthetic skills, artistic development/drama and theater skills, mental development/thinking skills, personal development/intra-personal skills, and social development/interpersonal skills.

## **3. Process drama**

Student decisions about socio-scientific issues do not depend entirely on science knowledge but also on political, ethical, and economic factors. Science drama can be employed as a teaching strategy to humanize science education (Nickerson, 2009). By its nature, the creative world in a drama affords the chance for first-hand interactive learning experiences and the resulting understandings that can be directly transferable to the real world. It is a way in which students make sense of the world around them; using dramatic play to practice life (Bowell & Heap, 2001).

Science drama is a broad term linking science and drama and can encompass many types of drama activities such as physical theatre, personification, scripted drama, role-play, animation, film/video. It is a way to share the wonders of science with a wide audience; it can enrich and inform both its audience and its creators and performers. Science drama consists of the story and liveliness of its performance (Yoon, 2006). The story is events, characters, and settings arranged in sequence. It enables people's emotional participation. The story is also viewed as a mode of knowledge and thinking. Science drama should be based on sound scientific ideas including some science terminology, or well-known scientists as a cast. The liveliness is from the present tense and action of participants. Liveliness reflects their understanding in a way that is meaningful to them. Science drama offers room

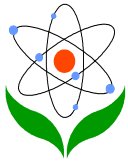




for students to talk, express, adapt, and evaluate their science knowledge and thought by its liveliness in a non-authoritative learning environment. In short, science drama gives a human nature to its authorized scientific knowledge by emotional and active participation. There are many ways to categorize science drama; for example, with-scripts/without-scripts; theme science (science concept /science history /science character); explorative (process) /semi-structured/structured (product), etc. The drama in this project is characterized as a with-scripts, science content-based, process drama.

Ødegaard, (2003) categorized science drama in to explorative (process), semi-structured (role-play), and structured. Structured science dramas are mainly teacher-initiated and presentational. The scripts are written and provided by teachers and students read or act the scripts. In the semi-structured drama, the teachers provide a role description, and context. The students then improvise according to their role. Explorative science drama, on the other hand, is student-initiated and experiential (Butler, 1989; Duveen & Solomon, 1994; Pantidos, Spathi, & Vitoratos, 2001; Solomon, 2002). The teachers do not select a play and then lead the participants through the proper skill acquisition necessary to perform that play. Rather, the students write their scripts and act. The play is by and for the students.

To help students produce a drama, the teachers must prepare students to meet the requirement of drama production (Bowell & Heap, 2001). To produce a drama, the students need; 1) personal and social ability, 2) performance skills, 3) knowledge and understanding about theatrical ideas and concepts, and 4) theme or the main idea of the play (Lewis & Rainer, 2005). The personal and social ability consists of interactive skills; teamwork, negotiation and problem solving as well as the ability to contribute ideas and critical evaluation to the process of making drama. Performance skills are needed in order to make students' ideas concrete including physical and vocal skills as well as technical abilities relating to design, stage, management and theater technology. Knowledge and understanding of theoretical ideas and concepts is the framework underpinning students' ability to make drama or present it to an audience. They need to develop a wide range of knowledge and understanding of the form and language of theater. The theme is the abstract issues and feelings that grow out of the dramatic action. It is a message delivered to an audience. To develop this element (Bowell & Heap, 2001), teachers should make children curious about knowledge and assist with and motivate research skills and



actively show the place of personal enquiry through the involvement of all the sense and through a total body experience in the acquisition of knowledge. This may be called student research. These requirements are considered in the design and have become the basic elements of student preparation session in the drama workshop of this project which will be elaborated in method section.

#### **4. The science of global warming**

The concept of global warming comprises three subordinated concepts related to one another namely the causes, process, and consequences of global warming. Their scientific conception is explained below.

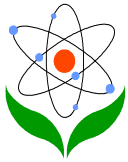
##### *4.1 The causes of global warming*

The heat is absorbed by heat-trapping gases in the atmosphere. This keeps the Earth in a temperature range that allows life to flourish. These gases are known greenhouse gases. There are a number of green house gases: carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>), water vapor, sulfur hexafluoride, and CFCs, etc. Earth's most abundant greenhouse gases are water vapor, carbon dioxide, methane, nitrous oxide, ozone, and CFCs. Water vapor, the most prevalent powerful greenhouse gas holding onto 2/3 of the heat trapped by all greenhouse gases, is also a consequence of global warming. Atmospheric CO<sub>2</sub> is produced by a number of sources including burning of fossil fuels by cars, electricity generating power plants, airplanes and deforestation. Methane is derived from rice paddies, bovine flatulence, bacteria in bogs, and fossil fuel production. Nitrous oxide (N<sub>2</sub>O) or laughing gas is produced either naturally in ocean forest or by humans in nylon and nitric acid production, the use of fertilizers in agriculture, and cars with catalytic converters

##### *4.2 Process of global warming: greenhouse effect*

The Earth receives energy from the sun in the form of visible light. Most of this energy is not absorbed by the atmosphere since it is transparent to visible light. The energy hits and warms up the earth. It then radiates back to the atmosphere in the infrared range or heat. The energy is, this time, trapped since the greenhouse gases are not transparent to infrared. They absorb thermal infrared radiation. As a result of its warmth, the atmosphere also





radiates thermal infrared downwards to the Earth's surface. This keeps the Earth's temperature steadily heated. This mechanism is fundamentally different from the mechanism of an actual greenhouse which isolates air inside the structure so that heat is not lost by convection. Anthropogenic global warming is a global mean temperature anomaly trend that results from an enhanced greenhouse effect mainly due to human-produced increased concentrations of greenhouse gases in the atmosphere.

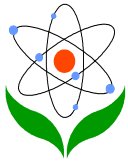
### *4.3 Consequences of global warming*

Increasing global temperatures are causing a broad range of changes: sea levels are rising; land ice in the poles is melting; and the amounts and patterns of precipitation are changing. Moreover, there is an increase in the frequency, duration, and intensity of extreme weather events, such as floods, droughts, heat waves, and tornadoes. Other effects of global warming include lower agricultural yields, further glacial retreat and disappearance, reduced summer stream flows, and species extinctions. In addition, diseases like malaria are returning into areas where they had been eliminated earlier.

## **Methods**

### **1. Research design**

The present paper is a report of the second phase of a two-year research project. The whole project was conducted in an ongoing research and development fashion. It is divided into three phases; Exploration, Implementation and Evaluation, and Extension. In the first phase, semester A, academic year 2008, one hundred and six Grade 7 students from one secondary school in Bangkok completed an open-ended Scientific Literacy Test on Global Warming which had been designed to explore students' perception, conceptual understanding of global warming and engagement in environmental action. The key findings were taken into consideration in the design of a 7-day process drama workshop that was implemented in the same school during a month break between semester A and B. In the second phase, which is the focus of this report, the effectiveness of the process drama workshop in terms of promoting scientific literacy on global warming was investigated. To disseminate process drama strategy to other teachers of science in charge with educating global warming, in the third phase, the workshop was modified to an intensive professional development workshop. The



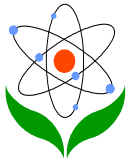
PD workshop was set up in Nakorn Prathom province during summer. The participants were encouraged to run a drama project in their schools in Semester A, academic year 2009. The researcher followed up these teachers offering assistance and advises on site. He examined how process drama was implemented and its effects on students' and a community's level of scientific literacy on global warming.

Critical instance case studies was selected as a research design since it would allow the researcher to be in depth in empirical examination of the selected group of students and teachers of unique interest within its real life context, with little or no interest in generalizability (Yin 1989; Davey, 1991). By this design, the researcher can employ multiple sources of evidence looking an issue from different perspectives for more valid and reliable useful data. This would inform him whether and how dramatic experience promoted scientific literacy on global warming.

## **2. Participants and setting**

There were 31 students participated in the drama workshop; 24 of them were lower secondary students (Year 12-14) and seven of them were high school students (Year 15-17). The drama workshop was initially opened for interested lower secondary students only. However, there were seven high school students who science teachers asked to be included since they had a strong interest in science drama and had been participating in environmental movements. Some of these high school students, mostly girls, were recognized by their teachers as the environmental activists of the school.

The students came from middle and upper class families. Most of the participants lived in the district where school was located; a central district of Bangkok. This district was known as the one facing serious, massive, traffic jams. The major reason for this is the ongoing construction of mega-projects: expressways, tunnels and flyovers, underground metro systems (MRT), and Bus Rapid Transit (BRT). The school is a special large sized public, co-educational, state secondary school with more than 4,000 students. It is fully equipped and still in very good condition. Moreover, the school has been given good and continuous financial support by parents' association. These funds have been allocated for the benefit of education, welfare and a healthy community within the school. The school has a science self-learning center where the students can have access to numerous



science textbooks, magazines, science fiction, posters, and internet. The center is, in addition, equipped with multimedia such as a video player, televisions, and a projector.

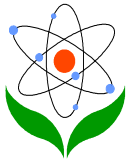
To create permanent public awareness about energy conservation, the school implemented a Green Learning Room program with financial support from the Electricity Generating Authority of Thailand (EGAT). The Green Learning Room offers a variety of interactive learning tools to educate school children on the link between energy use and the environment. In addition, the school, at an administrative level, has given importance to environmental issues, especially energy saving. It has run campaigns to raise environmental awareness and concern about global warming for its students. Therefore, the school accepted an invitation to participate and offered support including staffs to assist the researcher running the workshop as an assigned working committee and coordinating with student parents.

### **3. Research instruments**

Multiple data gathering techniques were used: a questionnaire, participant observation, a student journal and a drama script. Their description, development, method of data collection and analysis are detailed below.

#### *3.1. Scientific Literacy Test on Global Warming*

The Scientific Literacy Test on Global Warming (SLTGW) is an open-ended questionnaire measuring the level of scientific literacy on global warming. The questionnaire was validated by content experts and piloted with a cohort of 30 junior high school students similar to the target group. The questionnaire consisted of three sections. The first section, Perception of Global Warming, a list of nine key terms related to global warming, was provided asking students if they had heard of some keywords and if so, where from, and how they understood them. The key terms were greenhouse effect, climate change, coral reef bleaching, Kyoto Protocol, biodiesel, gasohol E20, diesel B5, non-renewable energy and renewable energy. The second section, Conception of Global Warming measures their conceptual understanding about the causes, processes, and consequences of global warming. The third section called Engagement against Global Warming; the students were asked whether they had participated in fighting global warming and how they did it.

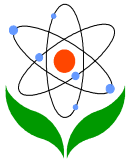


In some questions of the questionnaire, the students were encouraged to draw a picture or a concept map to illustrate their ideas.

SLTGW was distributed to the participants before and after the drama workshop to examine the effect of the dramatic experience on students' scientific literacy on global warming. It took two hours to complete. Data from the three sections of the questionnaire were analyzed differently. Data from the first section was used to produce frequency of those who had and had never heard the keywords. The definitions of keywords given by the respondents were examined. These were classified into scientifically or non-scientifically consistent. In the second section, responses to each question were carefully read, interpreted and sorted making a list of "big ideas" that represented each of the grouped responses. These ideas were compared with the scientific conception and classified into the following conceptual levels: Sound Understanding (SU), Partial Understanding (PU), Partial Understanding with Specific Misconception (PU&SM), Specific Misconceptions (SM), and No Understanding (N) according to the continuum of conceptual understanding developed by Abraham and Wilkinson (1994). Frequency of students holding a specific level of understanding is calculated. Below is a description of these levels:

- Sound Understanding (SU): Responses that included all components of the validated response;
- Partial Understanding (PU): Responses that included at least one of the components of validated response, but not all the components;
- Partial Understanding with Specific Misconception (PU&SM): Responses that showed understanding of the concept, but also made a statement which demonstrated a misunderstanding;
- Specific Misconceptions (SM): Responses that included illogical or incorrect information;
- No Understanding (N): Repeated the question; contained irrelevant information or an unclear response; left the response blank.

Assigning student ideas to certain levels of conceptual understanding is subjective. To avoid bias, inter-rater reliability was carried out. In doing so,



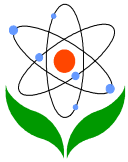
each item, fifty percent of responses were analyzed independently by trained two raters in addition to the researcher. Assigning conceptual label to written response must be agreed by all three raters. In case of disagreement, the raters shared their ideas explaining how they looked at the data and why the response should be labeled that way. The dialogue went on until they reached agreement. The researcher used this framework to analyze the rest of responses. As for the data from the third part, frequency of ways to stop global warming is produced. The results of the questionnaire before and after the workshop from the three sections were then compared.

### *3.2 Participant observation*

The aim of participant observation is to gain a close familiarity with the participants and their practices through an intensive involvement with them during the workshop. This results in detailed and accurate information on how process drama promotes learning. While in the setting, the researcher made careful, objective notes about what he see, recording all accounts and observations as field notes. Informal conversation and interaction with the participants was also recorded in the field notes. All activities in the workshop and students' performance in a performing day were also videotaped so the researcher could go over the data to make sure that no important points were missed. In addition, the researcher, by the end of each day, had a discussion with training assistants to describe and interpret the events of the day. Content analysis was used to make meaning of observational data. The core questions of content analysis were: "Who says what, to whom, why, to what extent and with what effect on student learning?" In this fashion, the communication content was categorized and classified for building up inferences (Miles & Huberman, 1994; Krippendorf, 2004).

### *3.3 Student journal*

A journal is a continued series of writings made by the participants daily throughout the workshop in response to their dramatic experiences. Every journal entry is individual. It contains a description of daily events, self reflections on what took place and expresses emotions and understanding about them. The data would inform the researcher: how process drama is processed; how it promoted scientific literacy on global warming; and student



satisfaction on the teaching strategy. The journal is written at end of a day and handed in the researchers. The researcher also used students' feedback to guide teaching in the following day. Content analysis is also used to make meaning of student voices in their journals.

### *3.4 Drama script*

A script is the dialogue and action of the drama the participants produced. It contains purpose, circumstances, main characters and their actions. It starts with a general plan and envisions how events unfold. The scripts are the final product of thoughts, values and interpretation. Therefore, it reflected student conceptual understanding of global warming, their concern, environmental responsibility and actions decided to take on the issue. The drama script is analyzed by the following procedure. First, the script is read from the start to the end to get an idea of what the story is about, where it takes place and how the characters behave. The researcher reads the script again and starts making notes about the plot, theme, logic, exposition, main question, action, cause of the action, resulting action, conclusion, and make interpretation.

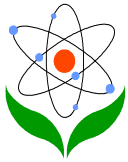
## **4. Drama workshop**

The intervention encompassed the workshop whose program content was validated by three drama educators who had experience in producing science drama. The workshop aimed to help these inexperienced students make a story and act it out on stage lively. The students are also expected to deliver the correct message about global warming to their audiences. The workshop last for seven consecutive days, October 4th-10th, 2008. Last two days, students stayed overnight at school. The program was divided into two sections; student preparation and drama production and contribution.

### *4.1 Student preparation*

The student preparation, the researcher, taking the shoes of a drama teacher, equipped the students with all needs to produce a drama as discussed previously in theoretical framework section; 1) personal and social ability, 2) performance skills, 3) knowledge and understanding about theatrical ideas and concepts, and 4) theme or the main idea of the play. These elements was rearranged and presented in details in chronological order as follows. As for





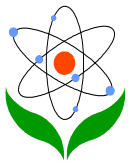
the personal and social ability focusing on interactive skills, it was embedded in other elements.

#### 4.1.1 Theme or the main idea of the play

The theme of the drama is the science of global warming covering the cause, process, consequences of global warming, raising awareness, concern, and campaigning for taking action against global warming. The research adopted various teaching methods to develop thorough understanding of this message.

##### 4.1.1.1 Doing experiments

As for the science part, the researcher employed scientific inquiry since it is a way we do science. Engaging students in discovery and scientific process improve learning and retention of scientific knowledge. After exchanging their prior knowledge about global warming, the students engaged in a series of laboratories focusing the cause, process, and consequences of global warming (Figure 1). This series was developed by The Queensland Sustainable Energy Industry Development Group, Queensland University of Technology, Australia.



**Figure 1:** *A series of lab exercise about global warming*



Students are presenting their existing ideas



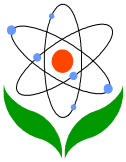
Extra CO<sub>2</sub> experiment



Students are putting up their promise in a heart shape paper on the wall

#### 4.1.1.2 Critical reviews of printed media

The students were engaged in a Hard Talk activity. In this activity, broadcast and web-based news about global warming were presented. The students identified purposes and key issues or arguments the writer made, along with important terms, recurring images and interesting ideas and examined how that text portrays the subject matter, questioning the sources that the writer might have used: personal experience, research, imagination, popular culture of the time, historical study, etc. They evaluated the accuracy of the texts, and whether or not they were scientifically based. If not, how it could be corrected was discussed.



#### 4.1.1.3 Watching a video

An Inconvenient Truth, a 2006 documentary film about former United States Vice President Al Gore's campaign to educate citizens about global warming via a comprehensive slide show was presented to the students for further discussion on the cause, effect, consequences and the solutions of global warming.

#### 4.1.2 Performance skills

To be trained to act naturally, the students need to have focus. Vipassana Walking, a Buddhist way of meditation, was applied (Figure 2). When their mind was ready, the students engaged in a series of drama exercises including Mirror, X-men, Emotion, Still Picture, and Yes, And? These were designed to practice their observation skills and quick response, imagination and interpretation, teamwork, and creative thinking.

**Figure 2:** *Acting class*



Students are doing meditation



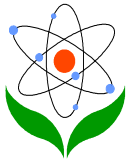
Warm up the throat activity



Mirror activity



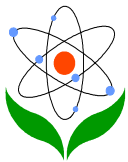
Human puppet show in the still picture activity



#### 4.1.3 Knowledge and understanding about theatrical ideas and concepts

There was a session in which the students read a short story and examined how the writer narrated the story (Figure 3). This led to a discussion of the dramatic structure, focused primarily on Gustav Freytag's analysis (MacEwan, 1900). According to Freytag's pyramid, a drama is commonly divided into five parts in sequence; exposition (providing the background information needed to properly understanding the story), rising action (complicating basic internal conflict), climax (turning point which marks a change), falling action (unraveling the conflict), and dénouement (concluding). Then the students watched a musical theatre and analyzed the basic elements of theatre (script, scenario, plan; the process; the product; and the audience), most recognizable figures including a director, a playwright, and actors and a production team including scenic designer, lighting designer, costume designer, sound designer, stage manager, props mistress or master and production manager.





**Figure 3:** *Making and developing a story*



Analyzing the elements of theatre



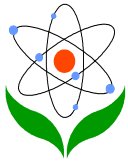
Students are presenting their story



Script writers are developing story and writing a drama script.

#### *4.2 Drama production and contribution*

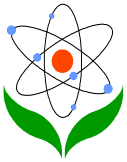
They work in group. They were assigned to create a drama story about global warming. The drama should aim at communicating basic scientific information about global warming (cause, process, consequences and cures of global warming) to the public; raising public awareness and environmental responsibility; and entertaining the audience. Five drama stories were written but only one with the highest votes was selected. The winning story was entitled **ๆ เราต้องจากไป** (in Thai), or “Maybe We Cannot Be Here” (see Appendix). The production teams were formed on a voluntary basis; director, director assistant, playwright, scene, lighting, costume, sound, stage, and props. The team of playwrights established the structure of the drama and overall framework, developed characters, created the dialogue and the visual and environmental elements of the work. The director, director’s assistant,



and playwright team act as a casting panel selecting a cast for actors for leading and supporting roles in the scripts. The consideration was based on the photo shoot taken on the first day, self-described personality on the application form, and the observation of their performance from the previous three days of the workshop. They presented a cast list to trainer teams for comments. After revising, the final cast list was announced.

The students went through several rehearsals (Figure 4). These assisted performers in learning dialogue and solidifying aspects of blocking and stage movement; and assisted the production team in technical stagecraft work including constructing and rigging scenery, hanging and focusing of lighting, design and procurement of costumes, makeup, making props, and recording and mixing of sound. The premiere of the drama to the public was on October, 15th, 2008. There were various groups of audience; mainly Grade 9 students, approximately 150 students; about 60 primary students from two schools nearby, the administrative and teaching staff and the students' parents.





**Figure 4:** *Drama production and distribution*



Painting the backdrops



Chum is painting a space gun



Q2Q rehearsal



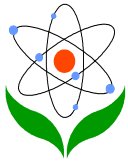
Run through



Costume fitting



The premiere of the drama



## Results

The results are presented in three sections: first, the students' perception of the keywords about global warming; second, the conceptual understanding of global warming; and third, the engagement against global warming.

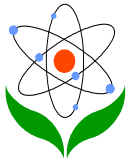
### 1. Perception of global warming

Student's perception of nine keywords related to the global warming issue before and after workshop the are presented in frequencies in Table 1.

**Table 1:** *Student's perception of the keywords related to global warming issue before and after the workshop (n = 31)*

Keywords	Number of students (before/after)		
	Never heard	Heard	
		Scientific based	Non-scientific based
1. Greenhouse effect	0/0	7/21	24/10
2. Climate change	2/2	0/10	29/19
3. Coral reef bleaching	28/0	2/14	1/17
4. Kyoto Protocol	18/2	1/16	12/13
5. Biodiesel	3/3	9/17	19/11
6. Gasohol E20	10/7	7/13	14/11
7. Diesel B5	19/16	2/5	10/10
8. Non-renewable energy	6/1	11/18	6/5
9. Renewable Energy	3/3	2/12	26/16

Before the drama workshop, it showed that some of the keywords related to global warming were more widely known among students than the others. These are greenhouse effect, climate change, biodiesel, non-renewable resource, and renewable resource. Coral reef bleaching and Kyoto Protocols are much less known by the students. Most of those who had heard the "popular" terms, however, gave non-scientific explanations. For example, on the concept of climate change, the students thought that the climate change was an unexpected fluctuation in weather conditions within a short period of time in a certain region. Scientifically, climate change is any long-term change in the statistics of



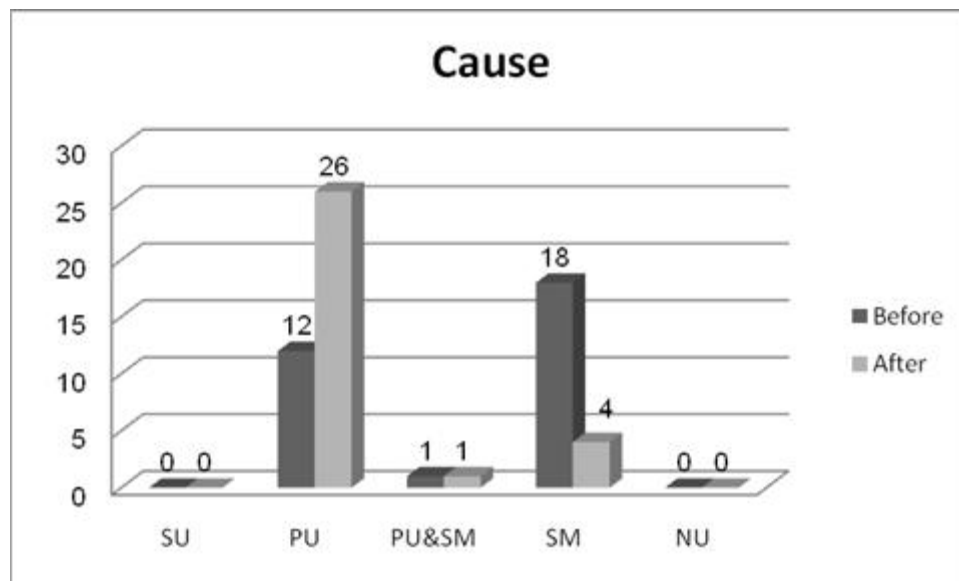
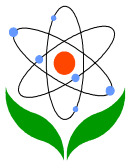
weather over durations ranging from decades to millions of years. It can be manifest in changes to averages, extremes and may occur in a specific region or for the Earth as a whole (De Freitas, 2002). On the concept of alternative energy, another example, the students could not identify the raw materials and the production process. Some of the students were confused between those of biodiesel and gasohol. After the drama workshop, however, it found that, the number of students holding a scientific based view was found to have increased, while those with non-scientific views dropped. The workshop could make the previously unknown/unfamiliar keywords; coral reef bleaching and Tokyo Protocol better known and aligned with scientific conception.

## 2. Conceptual understanding of global warming

### 2.1 Cause of global warming

In the pre-workshop, the majority of students held specific misconceptions (18 students: see Figure 5). Two of the most common ones are presented as follows. First, they thought that carbon monoxide, particulate matter such as dust and diesel exhaust, and extra sunlight from the sun were greenhouse gases. Greenhouse gases, scientifically, consist of varying amounts of water vapor and cloud (97%) with the remainder being gases like CO<sub>2</sub>, CH<sub>4</sub>, Ozone, and N<sub>2</sub>O (De Freitas, 2002). Second, the students thought that all sources of CO<sub>2</sub> emission were involved with human activities such as burning fossil fuels and deforestation. CO<sub>2</sub> was viewed as a pollutant or toxic gas in the air. In fact, this gas, as well as other greenhouse gases, also occurs naturally in the atmosphere and is essential to life on earth in the process of photosynthesis and respiration. Greenhouse gases are responsible for keeping the Earth warm; without them, the Earth would be frozen and lifeless. Although there were no students having sound understanding before and after the drama workshop, the number of students having partial understanding increased from 12 to 26. This group of students thought that there were only a few types of greenhouse gases. Greenhouse gases such as methane were hardly mentioned and few students referred to nitrous oxide, tropospheric ozone and water vapor. The number of students having specific misconceptions decreased from 18 to 4.

**Figure 5:** *Frequencies of students with different levels of conceptual understanding of the causes of global warming before and after the drama workshop*



## 2.2 Process of global warming

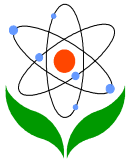
In the pre-workshop, the majority of students had a specific misconception and no understanding about the process of global warming, greenhouse effect (24 of 31: see Figure 6). There were two common specific misconceptions held among this group of students. First, they thought that global warming was a result of ozone depletion. The loss of the ozone layer and climate change are strongly connected; the hole in the ozone layer causes global warming. The ozone hole exposes the Earth to higher UV radiation levels from the sun. The following dialogue was taken from the conversation between the researcher and a group of students about the process of global warming just before doing a lab exercise on the first day.

R [Researcher]: How is the earth getting warmer?

S [Student] 1: Ozone layer acts like a blanket protecting the earth from the solar heat. When it is destroyed, the sunlight can get through and hit the ground more. It makes our earth warmer.

R: How is the ozone layer depleted?

S: Smoke from traffics, CFCs leaked from used air conditioners, hair spray, refrigerator and the like. These chemicals break down the molecules of ozone.



The second common alternative conception was that the students could not distinguish incoming, solar, short wave radiation from outgoing, long-wave, trapped rays. Most students thought it was solar rays that warmed the earth. The absorption of gases being dependent on wavelength was largely unknown by the majority of students. This indicates that students have difficulties viewing the Earth as a radiating object. Although, after the workshop, there were still no students having sound understanding (SU), the growth of scientific understanding was noticed. That is, the numbers of students having Partial Understanding (PU) increased from 7 to 21, while the numbers of Specific Misconception (SM) and No Understanding (NO) had decreased from 10 to 1, and 14 to 6, respectively. The conceptual change is evident in the following dialogue while they were doing the experiment.

*R:* What have you got?

*SI:* The temperature in the bottle A (the one with extra carbon dioxide) increases constantly.

*R:* What about the other?

*SI:* It also goes up but not as high as the bottle A?

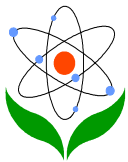
*R:* How would you explain such difference?

*SI:* The bottle A has more CO<sub>2</sub> than bottle B. This gas, I think, traps the heat and accumulates it inside the bottle.

After doing the experiment, the class made a link between the experiment and the real phenomena; how the experiment simulates the mechanism of global warming. From the notes in their journals, many students changed their alternative conception to a scientific conception. This alternative conception was highlighted in the script. The alternative conception and scientific conception are communicated through the drama script as follows:

*Thai PM:* Nowadays, there are so many countries heavily depending upon industrial sector. This sector emits greenhouse gases such as CO<sub>2</sub>, methane, water vapor, CFCs.



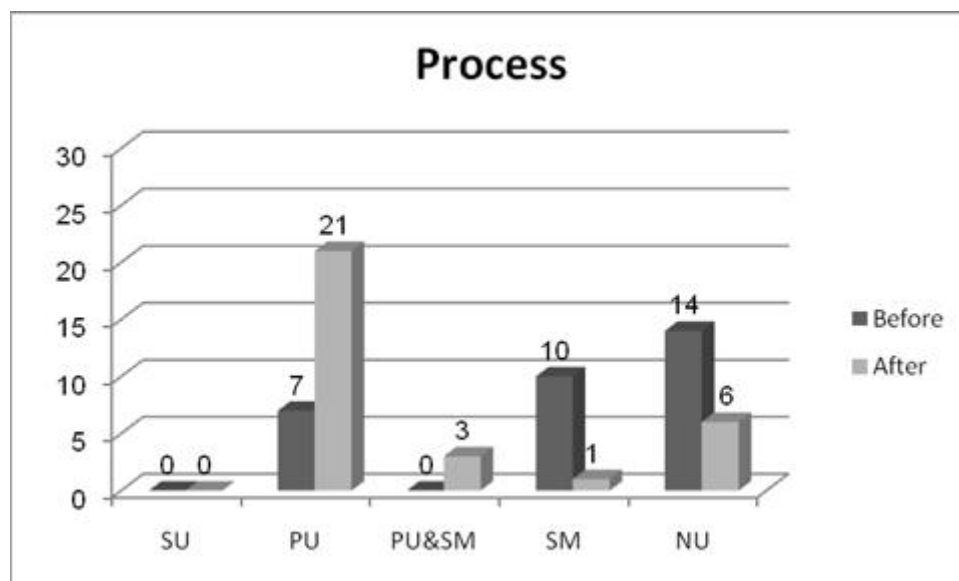


*Chinese Premiere:* CFCs, in particular, you know? It destroys our ozone layer. Without the ozone layer, almost all sunlight can hit the earth. The earth as the result is warmer. Now people can get skin cancer easier than ever.

*Korean PM:* No...No...You misunderstood. Listen! Listen! (Looks at other PMs and the audience). It doesn't work that way. The increase in the rate of skin cancer is not the consequence of global warming.

*President of the World:* (looks so confused) What exactly is the cause of global warming? (Look at his first secretary) Judith, call Prof. Brendon on. He is the expert.

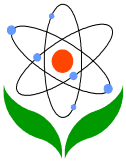
**Figure 6:** Frequencies of students with different levels of conceptual understanding of the process of global warming before and after the drama workshop



### 2.3 Consequences of Global warming

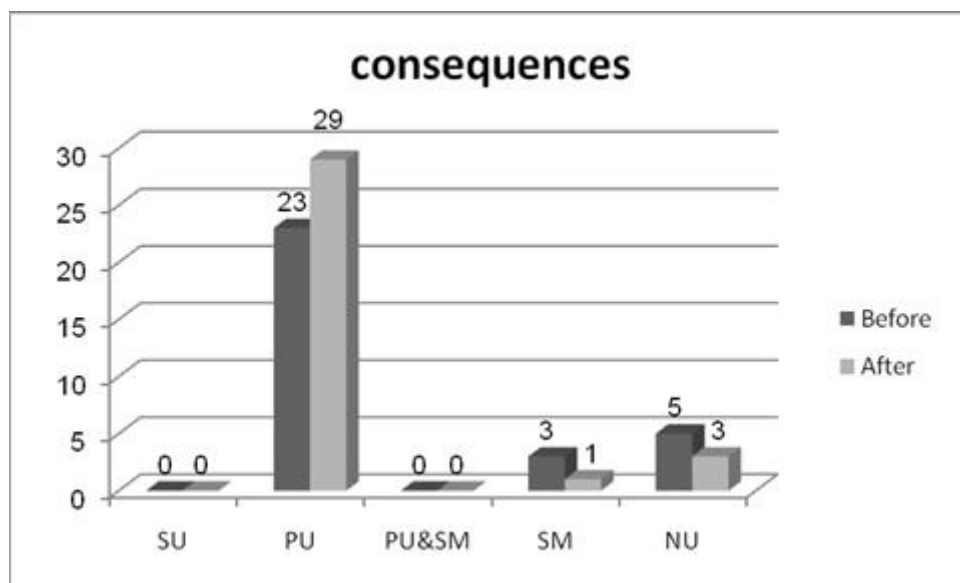
At the beginning, there were no students having Sound Understanding (SU). The majority of students had partial understanding of the consequences of global warming. However, after the workshop, the number of students holding Partial Understanding increased from 23 to 29 (See Figure 7). The students having Specific Misconception and No Understanding decreased. The partial understanding responses focused on large regional or





global climatic change, unexpected natural disasters and human health issues such as drought, flooding, heat waves, and the declining perennial polar ice cap in the Arctic. These students did not explain how these physical changes would threaten the economy, society, and ecosystem. Few students were concerned about a substantial reduction in crop yields that could lead socio-economic crises. None of them saw the ecological effect of global warming. They did not see how increasing global temperature affected physical and biological factors in an ecosystem and how this would trigger ecological change such as changes in range and seasonal behavior in certain species of plants and animals, reduction in ecological productivity and survival rate. Specific misconception was also found. The students thought global warming would result in an increase in the prevalence of skin cancer. This could be the result of the misconception of ozone depletion as the mechanism of global warming.

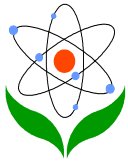
**Figure 7:** *Frequencies of students with different levels of conceptual understanding of the consequences of global warming before and after the drama workshop*



However, the students presented various consequences of global warming in their drama as shown the in following script.

At the opening scene:

People who have been suffered from global warming come on stage.



[Three sisters are swimming out]

*First sister:* I am so tired. I have been swimming for so long. I am sinking into the sea. Help! Help!

*Second sister:* You know [asks the audience]? In the past, we used to have ten thousand Rai [3954 acres]. Our land has been inundated by sea level rise. Now only 50 meter square is left over. How sad!!

*Third sister:* Sisters, shut up and listen! Look at that the ferry. It is approaching.

[Kai and her mother on the ferry saw the sinking girls and asked the crew to help. The girls, hence, were pulled up. Kai is back to her ice cream. Kai talked to her mother sadly.]

*Kai:* Mom, look at my ice cream. It is melting so quickly. It is unusual.

*Mom:* Don't be sad. Let's get the new one. We have plenty.

*Kai:* No, I don't want it anymore.

[Suddenly, two celebrities come out and start complaining to the audience]

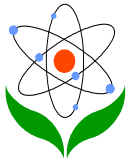
*Hom Yai:* Why today is so hot? I feel like being in a hot tub. Look at my skin, *Hom Dang*. Getting dark and shrinking. My SPF 999 sun block could not protect my tender skin [Screaming].

*Hom Dang:* What a pity! The weather is unpredictable. It is supposed to be cold now [Mid-December]. Last weekend I visited Mt. Everest, but there was no snow. Incredible!

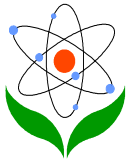
*Everyone on stage:* These must be the consequences of global warming!! We do need help. Mr. President of the World, where are you? [calling on and searching for]

### **3. Engagement against global warming**

Before the drama workshop, the students could suggest a number of ways to cut down the level of carbon dioxide in the atmosphere (Table 2) such as planting more



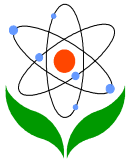
trees, recycling paper, saving electricity, riding a bicycle etc. However, most students could not explain how these environmental actions would solve global warming. Notably, most of their CO<sub>2</sub> reducing strategies were undertaken at the level of the individual. A very small number of students discussed the role of government, the private sector, state agencies, local authorities and community members in solving global warming. A few mentioned public hearings, conversations, and forums on global warming issues or the like in order to establish programs and policies to reduce in the concentrations of greenhouse gases. In fact, environmental solutions would be possible only if the commitment and cooperation from all stakeholders is established.



**Table 2:** on students' responses on the engagement against global warming

Things to do to stop global warming	Before	After
<i>Individual/ isolated view</i>		
Plant a tree	16	16
Protect and conserve forest	16	16
Use a cloth bag	16	8
Choose energy efficient appliances	15	14
Reduce waste	14	15
Use recycled paper.	14	15
Turn off electric appliances when not in use	13	15
Reuse shopping bag	12	14
Car sharing	10	15
Walking, biking instead of taking a bus	8	12
Buy refills	7	10
Replace a regular incandescent light bulb with a compact fluorescent light bulb	7	9
Choose products that come with little packaging	6	4
Create an energy efficient home.	5	14
<i>Communal / Integrated view</i>		
Get informed and educate others.	2	15
support green power	2	9
Join the virtual march/ run environmental campaign	-	9
Think about the impact of your investments	-	5
Tell the government to act	-	16
International cooperation	-	15
Others (one student per category)	4	4

By the end of the workshop, there was an increase in the number of students having an integrated way of tackling global warming for example, supporting green power, joining the virtual march and running environmental campaign, urging for the laws against global warming, calling for internal cooperation etc. Wannisa, in a written response, wrote, "We must ask our government to enact new laws that cap carbon emissions and require polluters pay for the global warming gases that they produce. This would have greater impact in a long run". Wannisa thought the solution of global warming would be successful once political leaders stepped in, the laws enacted and enforced. Jettana, a Grade 8 boy, another example, suggested using



social network to tackle global warming. In his journal, he wrote, "why not we use technology that we all are good at to stop global warming. We access Facebook every day. I will create one and invite friends to join in so we can share and learn tips to reduce the emission of greenhouse gas". From his text, he showed concern on global warming and contributed significant time and effort to the business. He fully invested in the mission and led other in carrying out the environmental action. The students' integrated view was also reflected in the following drama script.

*President of the World:* I agree with what you have just said but the situation on my planet is much worse than yours. We are getting to the dead end. Do you have any suggestions for what we can do to save our planet?

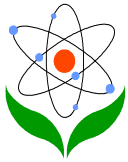
*Green Head:* I admire you. Once people are concerned, change will definitely occur. It is not too late, Mr. President. You should tell your people to plant more trees, use public transportation rather a private car, implement green technology, alternative energy, and use natural resources in a sustainable way. All these things would cut off the emission of greenhouse gas. Sincere and serious action is the key to success.

## Discussion

Before the drama workshop, it showed that some of the keywords related to global warming were more widely known among students than the others. Most of those who had heard these terms, however, gave non-scientific explanations. When probed in-depth, the majority of students held alternative conception about the cause, process, and consequences of global warming. In addition, the ideas about the engagement against global warming were on an individual basis. They perceived, understood and interpreted solving global warming in terms of the self. The action on climate change, in fact, can take many forms; individual action, protest action, political action, and international political framework.

The difference in students' perception of the nine keywords might be the result of the presentation of such terms by mass media in Thailand. According to Corbett and Durfee (2004), the issue of global warming presented in the media was quite superficial and alternative to scientific conceptions. So, it is often misleading the public. This confirms Marshall McLuhan's statement, "The medium is the message." Media coverage has focused on carbon dioxide and physical effect of global warming. In this study, the students understood greenhouse gas partially;



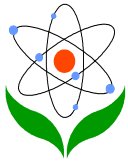


CO<sub>2</sub> was the one and only greenhouse gas. The majority of students thought that global warming resulted in catastrophes such as tsunami and a collapsed Thai temple which crashed by the sea during high tide. The great loss was shaken and stirred by Thai mass media influencing public perception on the consequences of global warming. The ecological, social or economic effects of global warming were unnoticed. Other sources of alternative conception are language and logic (Gautier, Deutsch, & Rebich, 2006). For instance, some students thought that the global warming would result in hot and dry weather, higher sunshine level, polar ice caps melting, sea level rise and flooding. This may be due the descriptive terminology "global warming" which describes the Earth as getting hotter and the use of logical thinking to derive their answers.

After the drama workshop, the results indicated that process drama could help develop all aspects of scientific literacy on global warming. In terms of conceptual understanding, it could make the previously unknown/unfamiliar keywords better known in scientific way. In the workshop, process drama provided an experience that allowed the students to explore, question, investigate and draw conclusions about global warming. The Drawing Global Warming activity on the first day made students clarify their existing knowledge. The exchange of these ideas led to conceptual conflict among students and they were encouraged to do experiments to test their ideas out. The series of lab exercises demonstrated the mechanism and the consequences of global warming.

In the critical review of global warming in the selected printed media activity on the first day, the students read, extracted the essential points and discussed the credibility of the texts from Thai mainstream newspapers and internet web-sites. Exemplars of alternative conceptions and common flaws in the news were identified and discussed. Linked to the lab exercises, they corrected the message. The class concluded in the end that the writers had a purpose for what they wrote; they would choose or emphasize facts and details which supported their purpose, and ignore facts which did not. As a scientifically literate person, the student needed to be skeptical of the implicit bias.

The discussion about the results of the experiment, issues in the Inconvenient Truth documentary film and the critical review of global warming in the selected printed media enhance students' understanding of the science, complexity, and mitigation measures of global warming. This is the message to the audiences. Their understanding was strengthened while they were making and developing a story.

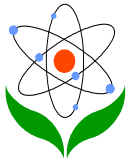


Each group of students had to elaborate about what and how to tell. In accordance with the studies of Bailey (1993), the script is the evidence that the children utilized play to clarify their scientific thinking. They mentally played with the concepts they were dealing with, incorporating them into an imaginary setting.

For example, the students had transferred their understanding from the lab exercise into a play. They knew that ozone depletion was actually not the cause of global warming and many of them had not thought this way at the beginning. When they wrote a script, this warning was communicated to the future audience. Soonthara said, “I strongly believe they [audience], just like us at first, would think that way [alternative conception]. So we decide to put this on stage and point out. Therefore, I hope they would get it and circulate the correct message to the public.” Play allows students to rehearse material that can be encoded into long-term memory and leads to deeper understanding of the concepts (Budzinsky, 1995; Butler, 1989). Students remembered the dramatic exercises vividly and could quote details of the text they used and acted. In process drama, the students had to think hard how to present the drama message in not only educational but entertaining and inspirational ways. This is the science and the art hemispheres of process drama.

In terms of engagement, the second element of scientific literacy, there is improvement. Based on the written response, student journal and drama script, their ideas on the solution of global warming are more integrated regarding all stakeholders in decision making process. This might be the result of the last activity in a lab series on global warming, called Heal the World, in which a member of the group was asked to list his or her daily activities that involved electricity consumption and consumption behaviors. The group calculated an electricity bill for a month using an assigned formula. The group interpreted, reflected on the results, making a connection to global warming, and created an Electricity Saving program to be implemented as well as other strategies to cut down greenhouse gas emission. Their program was shared and discussed with the whole class. Many of the curing strategies, in addition, were written on heart-shaped paper which was put up on the wall and exhibited throughout the drama workshop. In this way, the knowledge was made explicit and accessible for the students.

Not only their ideas have become more integrated, they have increased intensity of engagement against global warming. Based on the Ladder of Participation (Hart 1992), the workshop participants have stepped forward from being told what to do, to be informed, to lead and initiate action. Chum, in his journal, wrote, “Start with

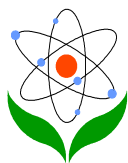


yourself! Educate yourself about global warming and then educate others. Talk to everyone you meet; neighbors, friends, family and community groups about ways to reduce global warming”. Korawee wrote, “I think everyone should jump in this circus. You should find your way to reduce the emission of greenhouse gas and you must act now. This is life threatening. It is social responsibility”. The students took leadership in environmental protection. The deep engagement after the workshop may be the result of the process drama’s learning environment that are aligned with Hart’s conditions for youth engagement: the students are respected, valued, trusted, feel appreciated, safe and comfortable; they feel they are working in a youth friendly environment and involved in a meaningful way; their voices are being heard; they are given the chance to be involved, make decisions, gain leadership skills and see their ideas realized; there is a social aspect to their involvement; their imaginations are touched and they are valued; and they are in a place where they have ownership and control.

Process drama involves personal involvement and commitment on the part of students, according to Erikson (1988), Kentish (1995) and McCaslin (2006). They become good at what they do only when they become totally immersed in it because a sense of ownership and responsibility may have been initiated. Drama can be used to motivate students and to show students’ talents, from acting to writing, in the science class. Some students, who usually do not participate in scientific discussions, might find themselves good at writing a script, production or acting.

## **Conclusion and suggestions**

This study indicates that process drama may be a successful way to achieve scientific literacy; the supreme goal of science education. It raises students’ curiosity and interest in science. This leads to the development of scientific knowledge, higher-level thinking, communication skills, and the application of knowledge in creative and productive way to solve real world challenge. Students’ personal experience with and through the drama is the key. Intimate involvement with the issues presented in a dramatic moment would challenge students to understand it, comment upon it and own its interpretation. Process is a medium through which any life experience may be explored with a focus on learning process rather the form of production. However, process drama is not a magic bullet in science education. It has many strengths as well as limits to consider such as the nature of science concepts, students’ knowledge background and



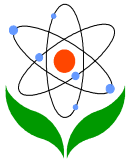
characteristics, time, classroom space and resource, budget etc. By this reason, teachers who would like to use process drama in their teaching need to have drama training so they will be able to use it in science lesson properly and efficiently. The researcher argues that process drama would make science education more humanistic and holistic. This is an innovative way of teaching science.

## Acknowledgement

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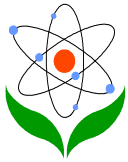
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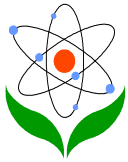
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## Appendix

### The summary of *Maybe we cannot be here!*

The story is opened with people who had been suffering from the consequences of global warming. They marched to the inter-government house asking the president of the world to solve the crisis. The president urgently set up a meeting with all country leaders and reached the conclusion that they would migrate to another planet. On the pilot survey, the president of the world and his cabinets decided to land on a bright green planet. They felt so comfortable there but later were caught by alien guards of Green Gov House to meet Green Head, the ruler of the Green planet. The world president shared his problem with Green Head. Green Head thought the president's decision was not on target. He suggested that it could only be solved if green policies were announced and implemented by all parties. The president agreed and decided to go back to earth doing so. At the end, Heal the World, a song of Michael Jackson was presented. Some parts of the song were translated into Thai.