

# The Effect of a Case-Based Reasoning Instructional Model on Korean High School Students' Awareness in Climate Change Unit

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The purpose of this study is to investigate the effects of the case-based reasoning instructional model on learning about climate change unit. Results suggest that students showed interest because it allowed them to find the solution to the problem and solve the problem for themselves by analogy from other cases such as crossword puzzles in an aspect of students' awareness of the designed model. This means students are motivated to study and the process of selecting and organizing educational content and teaching methods has to focus on students' active construction of knowledge. Therefore, the case-based reasoning instructional model can help researchers, teachers, and curriculum developers better understand students' process of learning and developing scientific knowledge about climate change.

*Keywords:* Case based reasoning, climate change, instructional model, scientific knowledge.

## INTRODUCTION

Our society is becoming more scientifically driven. In order to participate in making decisions about diverse socio-scientific issues, it is necessary to develop reasoning abilities and logical expression abilities based on scientific knowledge. Many global socio-scientific issues, including climate change, consist of undefined and unstructured problems (Gallagher et al., 1995). Developing the ability to handle the uncertainty of scientific problems is important (Bilgin et al., 2009).

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Uncertainty in science refers not only the complexity of the physical climate system but also that of social and cultural processes of individuals in society. The challenge of framing and communicating uncertainty about climate change is a symptom of the broader challenge of understanding and reasoning about the complex climate system (Curry, 2011).

With the curriculum reform in 2009, the Ministry of Education, Science, and Technology (MEST) in Korea now requires high school earth science courses to incorporate issues and scientific ideas concerning climate change (MEST, 2009). In order to understand the climate change phenomena, an ability to deal with uncertainty on several levels is necessary. The interdisciplinary and complex nature of climate change science results in an abundance of ill-defined problems, and finding solutions to such problems requires skills

### **State of the literature**

- The study aims to consider the theory of case based reasoning and clarify application and effect in school by mapping out a case based reasoning model suitable for teaching climate change.
- The designing process of case based reasoning model was obtained on the theoretical frames and conditions of the model found in the advanced research.
- The validity and reliability of the designed model was determined by experts in science education and applied in a school setting through discussing the strengths and weaknesses of the model.

### **Contribution of this paper to the literature**

- The designed model is going to contribute to the literature in that students in the case based reasoning class can explain climate change through reasoning of phenomenon or causal explanation of problem situation with knowledge of the case.
- The case based reasoning class can help researchers, teachers and curriculum developers to understand student's learning and scientific knowledge better about climate change.
- It is thought that teachers should give the opportunity of the designed case based reasoning lessons to students, so that more sophisticated and efficient actions of learning strategies can be produced as experimental knowledge.

that go beyond the relatively constrained problems generally presented in science textbooks (Schraw et al., 1995). Ill-defined or ill-structured problems are those that begin without all the information necessary to develop a solution or even to precisely define the problem, have no single right approach for a solution, have problem definitions that change as new information is gathered, and have no identifiable "correct" solution (Gallagher et al., 1995). Therefore, as climate change is a complex issue with different roots and many ramifications, learning about climate change requires students to exercise scientific reasoning skills, such as understanding, thinking, researching, and criticizing (Rebich & Gautier, 2005).

However, the traditional science teaching model overlooks the importance of students' reasoning processes regarding socio-scientific issues, such as climate change (Schraw et al., 1995). Developing an effective learning model that elevates students' reasoning ability has become a critical issue in recent science education. Traditional science instruction has tended to exclude students who need to learn from contexts that are based in the real world, graspable, and self-evidently meaningful.

In turn, Kolodner et al. (2003) stated that by utilizing the case-based reasoning learning model, students may develop understandings of scientific knowledge and change their intuitive concepts to scientific concepts. Kolodner et al. (2003) and Sun et al. (2005) found out that the case-based reasoning process encourages students to actively participate in solving a problem through an appropriate cognitive conflict and reasoning process by making them solve the problem through inductive reasoning that is based on past experiences. However, this approach is not perfect in that its procedural stage (He et al., 2010; Kolodner et al., 2003) needs to be more concrete (Kolodner et al., 2006).

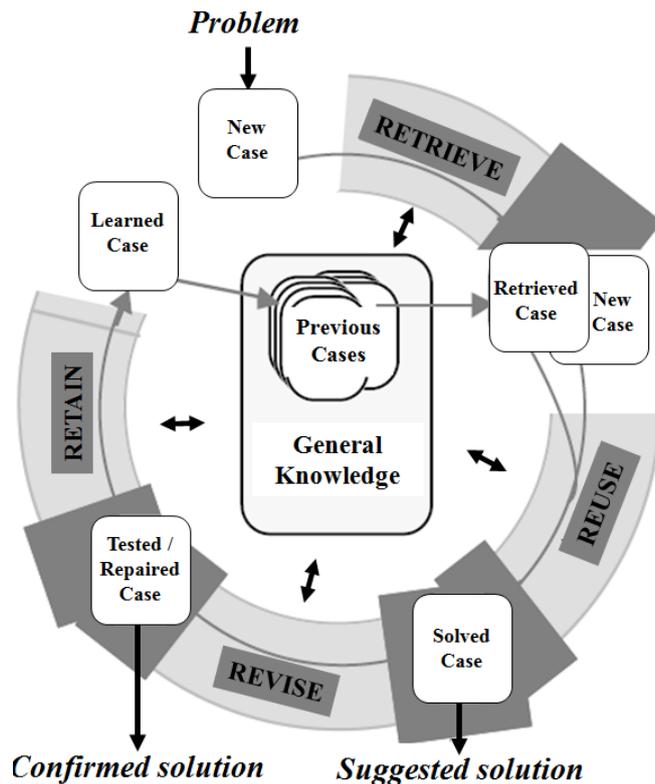
Therefore, an objective of this study is to develop a learning model for climate change based on the case-based reasoning process, see how the model influences students' understandings of climate change, as well as determine how students are aware of case-based learning in their classes.

### **Theoretical framework: The case-based reasoning model**

#### **Thinking and Problem-Solving Processes in Case-Based Reasoning**

Case-based reasoning is humans' intellectual ability to use prior experiences to explain, analyze, and come to a solution when they are faced with a new problematic situation (Kolodner, 1992). The thinking process used within case-based reasoning can also be explained as a cognitive process (Aamodt & Plaza, 1994). In other words, people use their diverse experiences to solve their problems. Therefore, various experiences help humans learn the necessary concepts and skills to accomplish a goal effectively and interpret experiences such that they can remember and use them to their benefit (Aha et al., 2009).

Also, case-based reasoning has a diagnostic character of *abduction* (Sun et al., 2005). In other words, case-based reasoning can not only facilitate problem-solving abilities based on past experiences but also can development scientific thinking by providing learning experiences to connect students' intuitive attitude and scientific concepts (He et al., 2010; Wheeler & Jones, 2008). If learners have a similar experience with a newly faced problem and remember how to solve it successfully, they can apply a solution that worked in the past to the new problem. But, unlike abduction, this reasoning process is not necessarily limited to their experiences. In case-based reasoning, learners can use and apply other people's experiences to a new problematic situation and solve the problem (Kolodner et al., 2003; Kolodner et al., 2006; Wang, 2006). Considering this, learners in the case-based reasoning class can solve a certain problem that is hard to find the

**Figure 1.** The process of case-based reasoning (Aamodt & Plaza, 1994)

solution to if they were only to use experienced examples (Craw et al., 2006; Kolodner, 1992) and can come to the conclusion that they can use various solutions that they have not directly applied in their own experience to solve their problem.

### Process and Components of Case-Based Reasoning

The process and components of case-based reasoning that Aamodt and Plaza (1994) suggested are shown in Figure 1. The process of case-based reasoning consists of 1) retrieving, 2) reusing, 3) revising, and 4) retaining. When a problematic situation is suggested, a learner can come to a solution by retrieving a similar case from their past experiences, reusing the searched case to the current situation, revising a previous solution to solve the new problem, and retaining a new experience about the prior case and the new case in the process (Aamodt & Plaza, 1994). Therefore, the process of case-based reasoning consists of a process of learning knowledge that is necessary to solving a problem (Craw et al., 2006; Patterson et al., 2008; Wang, 2006).

The process of case-based reasoning is the same with the problem-solving method based on declarative knowledge and procedural knowledge, and it can be explained as a teaching process to acquire knowledge necessary to solve a problem (Wang, 2006).

### Characteristics of Case-Based Reasoning Theories as Instruction

Case-based reasoning is as effective as learning from experience because it is just as easy to learn through retaining problem-solving experiences with facts as to learn from generalizing from experience (Aamodt & Plaza, 1994). Case-based reasoning utilizes knowledge learned in class, in diverse environments. Case-based reasoning helps develop the necessary knowledge in regards to solving problem to activate learners' cognitive activity (Aamodt & Plaza, 1994). It also provides opportunities for individualized learning in groups, which is important for cooperative learning such that individual experiences are reflected in the group (Kolodner et al., 2003; Wang, 2006). The last aspect is conditioning knowledge (Aamodt & Plaza, 1994; Kolodner et al., 2003; Wang, 2006). Therefore, the case-based reasoning lesson has the merits of formulating necessary cases of experiences to solve a problem in learners' cognitive structures and enable students to focus on a creative learning activity.

### RESEARCH OBJECTIVES AND METHODOLOGY

Having outlined the importance of the case-based reasoning theory, the objectives of this study are:

**Table 1.** Main instructional strategies in stages of case-base reasoning instructional model

Stage	Procedure	Main teaching strategy
Presenting a problematic situation	Introducing a lesson	1. Presenting the whole process of the case-based reasoning class specifically through the introducing lesson
	Motivating learning	2. Giving an opportunity for learners to expand their cognitive structure through areas of interest or concern
	Presenting a problematic situation	3. Giving an opportunity for learners to participate in problem-solving processes initiatively by presenting a practical problematic situation
	Recognizing a problem	4. Providing an opportunity for students to recognize the problem of a presented problematic situation or phenomenon
Search for cases	Searching for cases	5. Providing an opportunity to search for suitable cases by writing in former cases necessary to solve the problem (scaffolding)
		6. Using a strategy to arrange opinions suggested by students based on similarities
Use of case	Thinking of problem solving methods	7. Providing an opportunity to provoke a range of ideas as creativity and to search for former cases including others' experiences as a method to solve the problem
	Using a former case in problem solving	8. Providing an opportunity for group discussion for students to think about a problem-solving method by themselves
	Presenting a solution	9. Providing an opportunity to find similar former cases, namely providing a clue to solve the problem by themselves
	Verifying a solution	10. Providing an opportunity to determine if the cases used in problem solving are based on a hypothesis with appropriate grounds and claims
Modifying the case and problem solving	Modifying a former case	11. Providing an opportunity for students to present a solution (hypothesis) through an elaborating process
	Deciding whether or not to search for a case	12. Providing an opportunity to verify their solutions and speak their opinions through each group's presentation
Application and generalization	Checking for the solved case	13. Providing an opportunity to modify diverse variables and change the case such that it is suitable for solving the problem if the case is not appropriate to solve it
	Applying the case to a new situation	14. Providing an opportunity for students to judge if there is a need to search for a new case by using their own problem-solving judgment
		15. Providing an opportunity for students to check for the former case that learned by process of solving the problem
		16. Giving an opportunity to apply it to new problematic situation based on the useful former case used in problem solving

1) To develop a case-based reasoning instructional model focused on climate change for a high school Earth Science class in Korea.

2) To study how students make sense of case-based reasoning approaches in regards to problem solving in science class.

3) To explore the awareness about case-based reasoning held by high school students in Korea.

The initial case-based reasoning instructional model was designed based on theoretical considerations of case-based reasoning and researching science

instructional models. A final case-based reasoning instructional model was devised on the basis of students' awareness and the validity of experts' review processes through field application. Also, the application effect was analyzed by designing an experiment. Once developed, the instructional model was piloted according to the degree of validation, such that the degree of inconsistency with reality would be decreased.

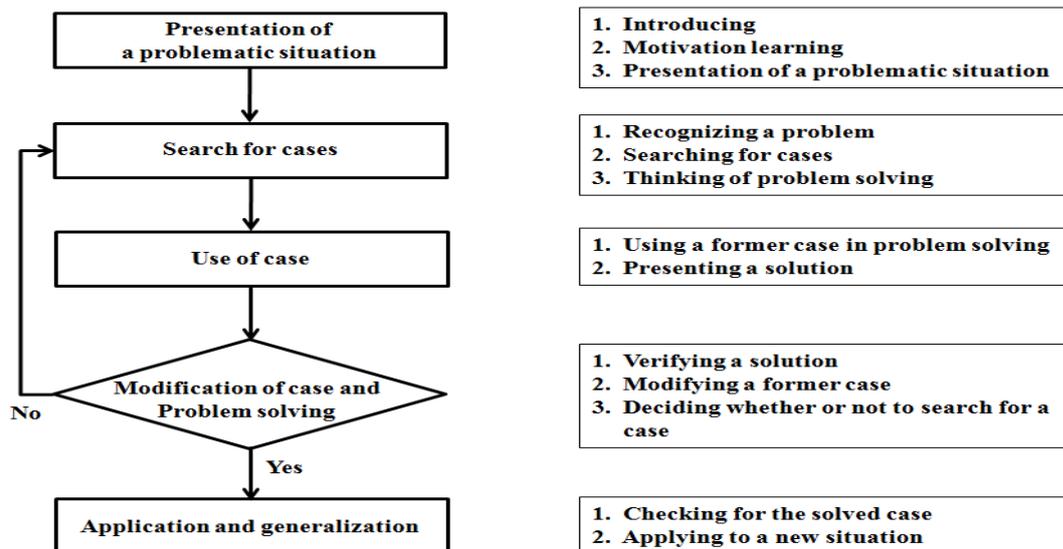


Figure 2. Designed case-based reasoning instructional model

### Participants

Twenty-eight sophomores from one science track class in an academic high school in Gyeong-gi province, Korea were chosen and the students participated voluntarily.

### Data Collection

Based on the theoretical frames and conditions of the case-based reasoning instructional model found in the advanced research, a designing process of the instructional model was conducted according to the research's basic procedure as follows. First, an initial case-based reasoning instructional model was designed, as shown, based on theoretical considerations of case-based reasoning and research of science instructional models. Second, the validity of the designed model was determined by experts in science education and applied in a school setting through discussing the strengths and weaknesses of the model. The field application was conducted by 28 sophomores from one science track class in an academic high school in Gyeong-gi province of Korea during 7 lessons of the Earth science I class (total 275 minutes) in the second semester of 2012. After the class ended, the participants were asked to answer a questionnaire about the lesson, and three days after the class, a semi structured one-to-one interview was conducted. Through the analysed result about the interview contents, the first modified case-based reasoning instructional model was suggested as outlined in Figure 2. Third, the validation method of the contents about the first modified case-based reasoning instructional model was used by experts' review used in validation of a model or an investigating tool in general

research. In the other words, the experts' review method suggested the model and assessed it by asking questions to the researcher using a simple checklist. The researchers who participated in the review were 5 experts who work in science education, 3 of whom were doctors and 2 of whom were in the middle of the doctor's course. This procedure enables experts to evaluate the accuracy of the research process and results because it gives an inter-rater reliability of the study (Lincoln & Guba, 2000). Based on the merits and demerits and improvement points of the instructional model determined through this validation process of the model, the second modified case-based reasoning instructional model was developed.

### Data Analysis

This study transcribed the interviews of twenty-eight students and divided the content into sentences. The interview materials were classified as A~Z, A'~B' and coded based on the main questions. These coded materials were classified as upper category by collecting similar coding through an inductive category. Thus the participants' interview material was analyzed by the inductive category based on the meaning and necessity of case-based reasoning.

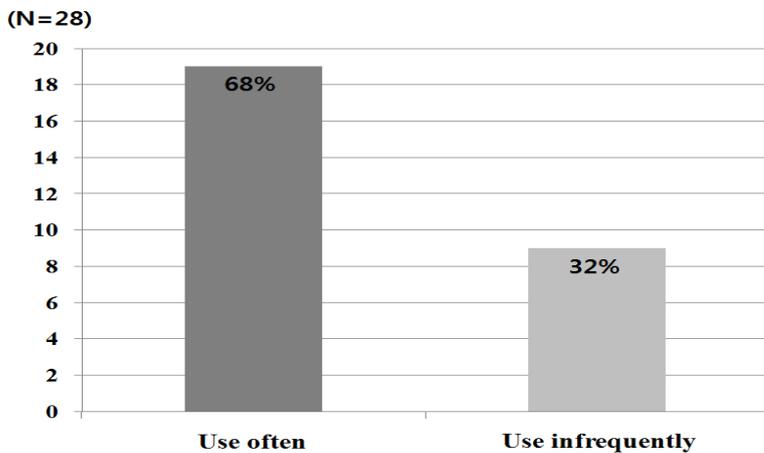
## RESULTS

### Designing the case-based reasoning instructional model

This research suggested the final designed case-based reasoning instructional model as shown in Figure 2; the main instructional strategies are shown in stages in Table 1.

**Table 2.** Students' awareness of the meaning of case-based reasoning

Number	Meaning of case-based reasoning	% (n=28)
1	A process of solving problems by using cases of experience	69
2	A process of reconstructing knowledge through a mutual exchange of opinions	54
3	A process of solving a problem by inference	75

**Figure 3.** Comparison of using of the case-based reasoning lesson

The first stage of the case-based reasoning instructional model is “presentation of a problematic situation”, the main activity of which is to attract learners to try to problem-solve the problematic situation by outlining the situation after introducing the lesson and motivating the students to engage in the learning process. The second stage is “search for cases”, through which students search for former cases, including others' experiences, as a method to solve the problem and find clues to solve it within the content of the problem. The third stage is “use of case”. It is the stage where the problem-solving method and solution are determined by modifying the concepts and principles related to regularity found in the case and building a hypothesis. The fourth stage is “modification of case and problem solving”. In this stage, the solution of a former case is verified and if the case is not appropriate to solve the problem, the former case is modified and the problem is solved. But it is also to find the other case necessary to solve the problem again if not solving it. The fifth stage is “application and generalization”. This stage stands for application and generalization and it can be invoked to indicate what has been solved, the outcome, solution, or conclusion, which is included the next steps to implement development of the idea. The main instructional strategies used in the stages are outlined in Table 1.

#### **The effect of application of the case-based reasoning instructional model**

This research attempted to consider a case-based reasoning theory to design a case-based reasoning

instructional model based on the theory and check for the application effect in a school setting. The results are as follows:

#### **Meaning of case-based reasoning**

Students recognized the meaning of case-based reasoning as three big categories (outlined in Table 2): a process solving problems by using cases of experience, a process of reconstructing knowledge through mutual a exchange of opinions, and a process of solving a problem by inference.

Sixty-nine percent of students regarded case-based reasoning as a process of solving problems by using cases of previous experiences to find the answer to a problem, as many people's previous experiences are used in the process of solving the problem. They thought that case-based reasoning is in the process of solving a problem by reviewing many previous experiences and finding a suitable case for the present problematic situation as “a learning process from experience” (Aamodt & Plaza, 1994; Kolodner et al., 2003; Wheeler & Jones, 2008). Fifty-four percent of students thought that case-based reasoning was a process of reconstructing knowledge through the mutual exchange of formulated opinions, which corresponds with an emphasis on a transfer of knowledge, such as correcting a misunderstood concept by sharing opinions in discussion or getting knowledge that one didn't have before by obtaining several cases of experience (Kolodner et al., 2003; Wang, 2006). Also, seventy-five percent of students defined case-based reasoning as a process of solving a problem by

inference, similar to the definition of “expanding a person's knowledge by interpreting new experience and combining them with memories” (He et al., 2010; Kolodner, 1992; Kolodner et al., 2003).

### **Necessity of case-based reasoning**

Participants think that case-based reasoning is necessary in science class because it makes concepts change, expands students' knowledge and increases problem-solving skills and thinking skills as shown in Table 3.

Fifty-four percent of students thought that case-based reasoning can derive a change of concept. Students recognized that case-based reasoning is a method to change a misconception to a correct scientific understanding. It seems that students knew which concepts were incorrect and were willing to change these concepts in the process of reading and asking the recorded cases. Sixty-one percent of students explained that case-based reasoning can expand their knowledge, as it assists them to gain knowledge they did not know and expand this knowledge through interactions with other people as “procedural processes” (Sun et al., 2005; Wang, 2006; Wheeler & Jones, 2008). Sixty-eight percent of students thought that case-based reasoning can improve their problem-solving skills and thinking skills.

### **Use of the case-based reasoning lesson**

As shown in Figure 3, sixty-eight percent of students expressed that they will use the case-based reasoning lesson often because it is a process to understand new knowledge and to solve a problem through a list of cases. However, thirty-two percent of students thought that they would not use the lesson because of the difficulty of sharing the group members' opinions, unsatisfactory experiences, the strange teaching method, and the difficulty of the science class.

### **Difficulties in using the case-based reasoning lesson**

As shown in Table 4, students participating in the lesson listed the difficulties of using case-based reasoning lesson as the following: a lack of understanding about case analysis, a lack of interest in participating in the discussion, the limited class time, a lack of knowledge about cases of experience, and teacher's insufficient help.

Forty-six percent of students listed the lack of understanding the case analysis as a difficulty of using case-based reasoning in science class. In other words, they have difficulty in classifying similar cases and thought that it is very difficult to apply because they

found that there were too many varied cases. Twenty-nine percent of students listed the difficulty of other people's opinions not being heard because of a leading presentation of one person, disagreement happened during the discussion, or there was a lack of participation by group members during the case-based reasoning lesson. Eighteen percent of students thought that using the case-based reasoning lesson was a very difficult way to learn one subject in a limited time. Also, thirty-two percent of students thought that it was hard to use case-based reasoning in a class because cases in textbooks are fragmentary and limited in number, whereas they have to find cases and use them in problem solving. Twenty-one percent of students had thought that this method was hard to do in the class activity without the help of teacher because the instructional style and terms or concepts of cases in searching for cases were too difficult.

## **FINDINGS AND DISCUSSION**

The educational use of case-based reasoning has been accepted as a key issue in science education (He et al., 2010). Although case-based reasoning has been widely accepted as a suitable and effective teaching strategy within scientific fields for many years and there is no research that clearly examines the nature of the learning that takes place, how case-based reasoning enhances learning or how students feel about using case-based reasoning in the subject about climate change.

The findings of this study indicate that overall the students found the experience of using case-based reasoning to be positive. In the meaning of case-based reasoning, students recognized the meaning of case-based reasoning as a process solving problems by using cases of experience, a process of reconstructing knowledge through mutual an exchange of opinions, and a process of solving a problem by inference. This is in the same context as “a learning process from experience” related to previous researches (Aamodt & Plaza, 1994; Kolodner et al., 2003; Wheeler & Jones, 2008). Also, participants thought that case-based reasoning is necessary in science class because it makes concepts change, expands students' knowledge, and increases problem-solving skills and thinking skills. This is similar to the process of case-based reasoning in that knowledge is gained through repeated procedural processes (Sun et al., 2005; Wang, 2006; Wheeler & Jones, 2008). But, students participating in the lesson listed the difficulties of using case-based reasoning lesson as a lack of understanding about case analysis, a lack of interest in participating in the discussion, the limited class time, a lack of knowledge about cases of experience, and teacher's insufficient help. Therefore, the students need to use inter-cooperative learning to

**Table 3.** Students' awareness of the necessity of case-based reasoning

Number	Necessity of case based reasoning	%(N=28)
1	Deriving the change of concept	54
2	Expanding my knowledge	61
3	Improving my problem-solving skills and thinking skills	68

**Table 4.** Difficulty in using the case-based reasoning lesson in science class

Number	Difficulty in using the case-based reasoning lesson in science class	%(N=28)
1	Lack of understanding about case analysis	46
2	Lack of interest in participating in the discussion	29
3	Limited class time	18
4	Lack of knowledge about cases of experience	32
5	Insufficient teacher's help	21

solve a problem through case-based reasoning by engaging in continuous discussion training (Jonassen & Hernandez-Serrano, 2002; Kolodner et al., 2003; Wheeler & Jones, 2008). Also, the lesson needs to let learners understand problems; outline opportunities that experts experienced through problem-solving processes in diverse situations; and focus on creative learning activities by helping students understand how to define, express, and solve a problem using knowledge as a tool (Aamodt & Plaza, 1994). As concluding these results, it is clear that the teacher's help is very necessary in science class even though case-based reasoning class has an ultimate purpose of students solving a problem through reasoning activities based on cases of experience. Therefore, this lesson needs to facilitate case-based reasoning learning by giving more weight to the learner's role and reducing the degree of teacher's help gradually rather than eliminating it.

#### LIMITATIONS AND FUTURE WORK

While this study has produced some valuable findings into how students are aware of a case-based reasoning model and how it contributes to their learning in the climate change topics, it does contain some limitations. First, the response rate in the case-based reasoning model was low so it is hard to generalize the results for all students studying in this model. Second, the student comments presented in the interview were drawn from a limited number of response. Therefore, further in-depth analysis of a larger number of responses might uncover variations in differences associated with student characteristics related to gender or age not evident from this small sample. Third, the results are related to one instructor's use of case-based reasoning model in teaching for climate change topics, so it cannot be sure if a different instructor would receive the same or similar results. Finally, we are unable

to determine whether students who used the case-based reasoning model will be more successful in applying students' learning and reasoning thinking processes in the climate change topics than those taught by a different method.

#### CONCLUSIONS AND IMPLICATIONS

This research considered case-based reasoning theory, designed a case based reasoning instructional model based on theory, and checked for the application effect in a school setting. The 5 stages and 13 subcomponents of process were presented as follows: presenting a problematic situation (introducing, motivating learning, presenting a problematic situation), searching for cases (recognizing a problem, searching for cases, thinking of problem solving), using of case (using a former case in problem solving, presenting a solution), modifying of case and problem solving (verifying a solution, modifying a former case, deciding whether or not to search for a case), and application and generalization (checking for the solved case, applying to a new situation).

Also, the results of this study contribute significantly to our understanding of both the students' experience in using case-based reasoning and how students are aware that it assists their learning in the subject about climate change. First, students recognized the meaning of case-based reasoning as a process of solving a problem with cases of experience, a reconstruction process of knowledge through exchange of mutual opinion. It can be clarified that they think of the definition of case-based reasoning as similar to a "learning process based on experiences", a "transfer of knowledge" and "a process of expanding knowledge". Second, students recognized the exact meaning of case-based reasoning that solves the present problematic situation through reasoning ability to explain a problem exactly and

various intellectual process about the similarities and differences of cases like 'crossword puzzle'. These results correspond with a process of being problem solver or learner through appropriate reasoning to a goal of case based reasoning. Finally, students were satisfied with problem-solving process by cooperative learning and it is in the same vein of formulating of inquiry community to discuss, explain and learn what they understand in a cooperative learning as a teaching factor of case-based reasoning instructional theory. The findings indicate that overall the students found the experience of using case-based reasoning to be positive; both in terms of improving learning experiences and in increasing interest in the subject about climate change.

Some practical implications from this study are that the case based reasoning class can help researchers, teachers and curriculum developers to understand student's learning and scientific knowledge better about climate change. Therefore, this study indicates that teachers should give the opportunity of case based reasoning lessons to students, so that more sophisticated and efficient actions of learning strategies can be produced as experimental knowledge according to the learning situation is internalized in student's existing knowledge system.

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