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FOSTERING CONCEPTUAL CHANGE BY COGNITIVE CONFLICT BASED INSTRUCTION ON STUDENTS' UNDERSTANDING OF HEAT AND TEMPERATURE CONCEPTS

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ABSTRACT. The purpose of this study was to investigate the effectiveness of cognitive conflict based physics instruction over traditionally designed physics instruction on preservice primary school teachers at grade 2. The subjects were 82 (27 boys, 55 girls) second grade pre-service teachers in two classes. One of the classes (42 students) was randomly assigned as experimental and the other class (40 students) assigned as control group. Both groups were taught by the same instructor. While the experimental group received cognitive conflict based physics instruction, control group were taught by traditionally designed physics instruction. The data were obtained through Thermal Concept Evaluation test (TCE). Prior to instruction, students in both groups were pre-tested by TCE in order to determine their initial understanding of heat and temperature at the beginning of instruction. The same tests were applied as posttest after the instruction. Independent samples t-test on pre-test scores showed that there was no statistical significant difference between experimental and control group at the beginning of the instruction in terms of understanding of heat and temperature concepts. ANCOVA results showed that mean scores on the post-TCE of students in experimental group were significantly higher than those of the control group. While interaction between gender difference and treatment made a significant contribution to the variation in achievement, gender difference did not.

KEYWORDS. Misconception, Conceptual Change, Cognitive Conflict, Heat, Temperature.

INTRODUCTION

As a human being, students have natural tendency to understand the physical world. Students construct their own naive concepts as a result of their observation and investigation of the physical world (Driver, 1989; Osborne & Freyberg, 1985). When they confronted a problem in everyday live, they try to solve it by their naive conceptions (Petersson, 2002). Research education over the past 30 years showed that these naive conceptions, in this paper called alternative conceptions, are common to many students independent of their age and culture (Yeo & Zadnik, 2001). Students' alternative conceptions in physics are well documented in the literature (i.e., Ma-Naim, Bar, and Zinn 2002; Maloney et al., 2001; Athee 1993; Heller & Finley, 1992; Feher and Rice 1992).

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From a constructivist viewpoint of learning, knew knowledge is constructed upon the existing one. Therefore, one of the factors in learning is learners' pre-existing knowledge, usually alternative conceptions, about the topic. Since the alternative conceptions are usually not consistent or partially consistent with currently accepted scientific knowledge (Wiser & Amin, 2001; Solomon, 1992), they can distort new learning (Novak, 2002). It is reported by the physics education researches that traditional instruction is mostly ineffective in changing these alternative conceptions as they are resistant to change and persistent (Eryilmaz, 2002).

Since many concepts in physics are abstract and can not be directly observable, it is natural that students come to physics class with many alternative conceptions. Heat and temperature concepts are very abstract (Harrison, Grayson, & Treagust, 1999) and difficult subjects not only for students but also for scientists and adults (Lewiss and Linn, 2003). This paper describes one model and investigate it's effectiveness for changing students' alternative conceptions in heat and temperature concepts.

ALTERNATIVE CONCEPTIONS IN HEAT AND TEMPERATURE

Concepts related to heat and temperature are directly related to physical environment of living organism. Hence, heat and temperature are not directly observable quantities, concepts developed by students originated from the interpretation of ideas gained from everyday experiences (Leura, Otto, & Zitzewit, 2005). In addition, culture and language are the effectual factors for developing concepts related to heat and temperature (Lubben, Nethisaulu, & Campell, 1999; Lewsis & Linn 1994). On the other hand, textbooks may contribute and/or strengthen students' alternative conceptions in heat and temperature (Leite, 1999). So, it is likely that students come into thermodynamics course with common alternative conceptions related to heat and temperature concepts.

Alternative conceptions in thermodynamics usually arise from substance-based conceptions (Harrison, Grayson, and Treagust, 1999; Ericson, 1979,). For example students thought that heat is a substance, something like air or stream which could be added or removed from an object, very similar to the caloric theory of heat held by scientist in 8th century (Brush, 1976). Most students, as well as adolescents, could not differentiate the terms "heat" and "temperature" and they use these terms interchangeably (Harrison, 1996; Jara-Guerro, 1993; Kesidou & Duit, 1993; Ericson & Tiberghien, 1985). Usually, this mutual substitution imitate not only to everyday conversation but to TV programs and technical reports. For example, it is common to hear that "the heat of the day rises and reaches a peak in the afternoon" while watching weather report on TV. Most students tend to reason that different sensations mean different temperatures. Students encountered difficulty in accepting that different objects are at the same temperature when left in same environment for a long time (Thomaz et al., 1995). The temperature of an object is seen as a characteristic of the material from which the object is made. Many students taught that heating a body always increases temperature of an object (Yeo & Zadnik, 2001). An extensive list of alternative conceptions related to thermodynamics was provided by Yeo & Zadnik (2001).

Students may answer questions in a test correctly in formal settings but these students usually fall back to their alternative conceptions while applying to everyday situations (Kolari & Savander-Ranne, 2000; White, 1992). Not only students but also scientists also have difficulties applying their scientific knowledge related to heat and temperature to everyday situations. For example, scientists gave different answers to a question of relative insulating properties of aluminum foil and wool.

COGNITIVE CONFLICT AS A BASE FOR CONCEPTUAL CHANGE

Student alternative conceptions that are grounded in everyday experiences are resistant to change (Harrison, Grayson, and Treagust, 1999; Driver, 1989; Hameed, Haekling, & Garnet, 1993; Osborne & Freyberg, 1985). High school students have difficulties with energy concepts, the particle model, and the distinction between heat and temperature (Kesidou & Duit, 1993). Furthermore, some students complete thermodynamic courses with many of their alternative conceptions unchanged (Carlton, 2000; Thomaz et al., 1995). It can be concluded that the instruction they receive unaffected their alternative conceptions. Moreover, scientists also have difficulties with heat and temperature concepts (Lewis & Linn, 1994). Although they may make more accurate predictions than students, they have difficulty in explaining everyday phenomena (Lewis and Linn, 2003; Tarsitani & Vicentini, 1996).

Use of a conceptual change learning models is one way of closing the gap between children's science and scientists' science (e.g., Posner e al., 1982; Hewson, 1981). Most of the conceptual change models are grounded on Piaget's ideas and notions of constructivism (Gega, 1994; Hynd et al., 1994; Stofflett, 1994; Hewson & Hewson, 1983; Posner et al., 1982). These methods suggests creating dissatisfaction in student's mind with his alternative conception, in this paper called cognitive conflict, followed by strengthening the status of the preferred scientific conception.

On the other hand, peer/social interaction and group discussion are important factors leading conceptual change as social constructivism insists (e.g., Uzuntiryaki, 2003; Brophy, 1986; Vygotsky, 1978). According to conctsructivist learning approaches knowledge is socially constructed (Duit, 2002) and intrinsic motivation that can be generated via group discussion, play an important role on knowledge construction (Pintrich, Marx, & Boyle, 1993). The learning method used in this study considered the importance of both cognitive conflict and peer interaction.

Since 1990's, cognitive conflict based instructions have been extensively used in science education. Several studies concluded that that cognitive conflict has an important/positive effect on conceptual change (e.g., Lee et al., 2003; Kim, Choi, & Kwon, 2002; Stern, 2002; Kwon, 1997; Druyan, 1997; Niaz, 1995; Thorley & Treagust, 1989; Hashweh, 1986; Stavy & Berkovitz, 1980). Lee et al. (2003) & Kwon (1997) are insisting the need for cognitive conflict in order to conceptual change takes place. Kwon & Lee (1999) demonstrated that students who had higher level of conflict showed very high rate of conceptual change from unscientific to scientific conceptions, while the low level conflict group showed very little improvement. Ting and Chong (2003) concluded that cognitive conflict fosters conceptual change. Zohar and Aharon-Kravetsky (2005) found that students with high academic achievements benefited from the cognitive conflict teaching method. On the contrary, there are some researchers who dispute the effectiveness of cognitive conflict on conceptual change (Limon, 2001; Hewson, Beeth, & Thorley, 1998). Some researchers (Dekkers & Thijs, 1998; Elizabeth & Galloway, 1996; Dreyfus, Jungwirth & Eliovitch, 1990) argued that instruction based on cognitive conflict do not necessarily promote conceptual change. Students often refuse to accept ideas in direct conflict with their alternative concepts (Bergquist & Heikkinen, 1990).

CHANGING STUDENTS ALTERNATIVE CONCEPTS IN HEAT AND TEMPERATURE

Some empirical studies conducted to change students alternative conceptions related to heat and temperature. These studies basically use constructivist and/or conceptual change teaching strategies to promote conceptual understanding. Most of them used cognitive/conceptual conflict as a key concept (e.g., Leura, Otto and Zewitz, 2005; Thomaz, 1995; Satvy and Berkovits, 1980)

Satvy and Berkovits (1980) used cognitive conflict in developing a teaching strategy which is aimed at advancing children's understanding of the concept of temperature. Their findings indicated that training by conflict did improve children's understanding of the concept of temperature both in individual and in classroom training situations. Thomaz et al. (1995) used a constructivist teaching approach to teach heat and temperature concepts at introductory level. His findings suggest that the model has potentialities for promoting a better understanding of the phenomena concerning heat and temperature. Harrison, Grayson, and Treagust (1999) used inquiry based teaching model coupled with concept substitution strategies to restructure student's alternative conceptions related to heat and temperature concepts. They found that students progressively accepted greater responsibilities for his learning related to heat and temperature concepts, was willing to take cognitive risks, and become more critical and rigorous in both written and verbal problem solving. Ma-Naim, Bar, & Zinn (2002) used conceptual change oriented approach to improve teachers' understanding of thermodynamics concepts.

Their results implied that teachers in the conceptual change approach teaching model has grater gains than their control group counterparts. Another inquiry based teaching method was used by Jabot and Kautz (2003) who showed the impacts of teaching and preparation of physics teacher in the case of thermodynamics. Their results suggested that guided inquiry group had greater learning gains. Clark and Jorde (2004) analyzed the effect of an integrated sensory model within thermal equilibrium visualizations. They found that students in the experimental tactile group significantly outperformed their control group counterparts on posttests and delayed posttests. Leura, Otto and Zewitz (2005) developed pedagogy, called misconception-guided instruction, based on conceptual change theory. Their results suggest that misconception-guided instruction promotes students understanding of heat and temperature concepts.

Consequently, it can be said that instruction aimed to change students' alternative conceptions in heat and temperature is somewhat effective. This paper discussed the effectiveness of instruction based on cognitive conflict to promote students conceptual understanding of heat and temperature concepts.

METHOD

Purpose

The purpose of this study was to examine the effectiveness of cognitive conflict based instruction (CCI) over traditional physics instruction (TPI) on pre-service primary school teachers in terms of understanding heat and temperature concepts. The specific questions that were answered by this study were:

1. Is there a significant difference between effects of CCI and TPI on students' understanding of heat and temperature concepts?
2. What is the effect of interaction between treatment and gender difference on students' understanding of heat and temperature concepts?
3. Do previous understanding, treatments, gender, and the interaction between treatment and gender explain a significant portion of the variation in improving students' understanding of heat and temperature?

Design and Subjects of the Study

The subjects of the present study consisted of 82 (27 male, 55 female) second grade pre-service teachers in two classes of the same instructor. Students' native language and language of instruction was Turkish. Each of two instructional methods was randomly assigned to one class after individuals were already in each class. The data were obtained from 42 students in the experimental group and 40 students in the control group.

Instruments

Thermal Concepts Evaluation Test (TCE). To asses students' conceptual understanding of heat and temperature concepts Turkish version of Thermal Concept Evaluation (TCE) developed by Yeo and Zadnik (2001) was used. The TCE targeted students' alternative concepts that were derived from misconception research, and posed questions in the context of everyday situations. The TCE consisted of 28 multiple-choice questions. Since TCE does not include question related to thermal insulation, two questions were added to the original test (see Appendix A). There are five categories in TCE: (1) heat, (2) temperature, (3) heat transfer and temperature change, (4) thermal properties of materials, and (5) thermal insulation. Each question consisted of a situation followed by statements that included common alternative conceptions related to thermodynamics. The TCE asks students for the 'best' rather than 'right' answer.

The test was translated and adapted to Turkish by the author. The pilot study of this test was applied to 430 second year students at Department of Elementary Education of Izzet Baysal University, Turkey. The reliability of the test was found to be 0.71 which is an acceptable value for a cognitive test (Maloney et al., 2001).

In order to investigate the effect of treatment on students' understanding of heat and temperature concepts, TCE was applied as a pre and post test to all subjects of this study.

Treatment

The study took approximately 3 weeks. A total of 82 students were enrolled in two classes of the same instructor at Department of Elementary Education of Izzet Baysal University, Turkey. There were two modes of treatments in this study. The control group received Traditional Physics Instruction (TPI). The experimental group taught with Cognitive Conflict based Instruction (CCI).

Throughout this paper Traditional Physics Instruction refers to the following teaching strategy. The teacher followed lecture and discussion method to teach concepts in thermodynamics. The students studied physics textbook on their own before the class hour. The instructor structured the entire class as a unit, wrote notes on the black board about the definition of concepts, and solved enough number of quantitative problems. The main principle was that knowledge resides with the instructor and that it is instructor's responsibility to transfer knowledge to students. When the instructor finished his explanation, some concepts were discussed through instructor directed questions. The instructor solved some chapter end problems in their textbook on the black board. The classroom typically consisted of the instructor presenting the "right way" to solve problems. The instructor assigned some of the chapter end problems to students as homework. In the lab hours of TPI students did the experiments in their laboratory manual. Before coming to lab hours, students read the manual on their own and made some preliminary work, e.g., write some theoretical framework of the experiment, answered questions about the theoretical base of the experiment. In the laboratory, they followed the manual to make the experiment, take data, analyze data, come up to results and accordingly write the report of the experiment.

The experimental group received Cognitive Conflict based Instruction (CCI). Students were set to two or three peers. In this group, whenever possible, the instructor demonstrated an anomalous situation to activate students' alternative conceptions. If an experiment possible, students did the experiment and come up the result that contradict with their pervious conceptions and set students in cognitive conflict. The students were asked to discuss the result of the experiment and their previous ideas with their peers. This enabled them to interact with their peer to exchange their ideas and their observations from the experiment. If an experiment is not possible, the instructor asked students to discuss the situation with their peer. Then the instructor collected different ideas about the situation on the board and discussed them with the class. Finally, correct ideas were determined and explained in detail. If possible, the instructor used analogies to explain the phenomena.

An example for cognitive conflict situation was as follows: Students were asked what they think about the temperature of metal and vynlex (artificial leather) part of their seat. Most of the students were thought that metal part of the seat was colder than vynlex part. The students allowed to measure temperature of each part and took notes. The temperature of metal and vynlex part was measured with a multimeter that is capable of measuring temperature by touching through a thermocouple. This type of devices can be obtained easily from electronic shops. In Figure-1 a student measures metal and vynlex part of his seat.

Figure-1: Student measures metal and vynlex part of his seat. He see that both parts were at the same temperature (19^{o}C).

Students see that both parts were at 19 °C. This set them in a cognitive conflict with their previous idea. Students discussed possible reasons of this result with their peer. Then, students were asked to do another experiment. In this experiment students were provided three bowls containing water at different temperatures: 0 °C (yellow bowl), 20 °C (green bowl), and 40 °C (brown bowl). Students were asked to place one hand in the yellow bowl and other hand in the brown bowl. They were asked which one is "hot" and "cold". After a minute they were asked to place the cold hand in the green bowl and described the temperature as being hot. Next the hot hand is placed in the green bowl and this time the temperature is described as being cool. After the experiment students were asked questions about the result. For example,

Although the water in the green bowl was the same, once you decided it as hot, and once you decided as cold. So do you think it is possible to determine temperature of objects with our sensation?

The students discussed and decided that:

It is not always possible to determine temperatures of objects by touching

Then they were asked to think about their feelings about temperatures of metal and vynlex part of their seat. Students come up to the following conclusion

Since we could not correctly determine temperatures of objects by touching, feeling metal part as being cool does not necessarily mean that it is actually colder than vynlex part.

The key question asked by the students:

Our sensation tells us something, we know that it may not be temperature. So what is the thing we sense?

This question is not directly answered. Students will answer this question by themselves with doing another experiment. Students were given brass and silver rods about 25 cm long. They were asked to put the one end of the rods to the radiator and measure temperatures of other hand in 10 seconds interval. They were directed the questions:

Which temperature increases rapidly?

Why silver first becomes hotter than brass?

Could the answer is the difference of rate of heat conducted through the rods?

Students were left to think and discuss the answer of these questions with their peer. It was seen that, they taught:

Since the rate of heat conducted through silver is more than brass, silver becomes first hot.

Then they were asked to think about the rate of heat transfer when they touch to metal and vynlex part of their seat. They concluded that the rate of heat conducted through metal part is much more than vynlex part. They were asked

So, do you think that we could sense the rate of heat transfer rather than the temperature?

Students decided that what we sense is the rate of heat transfer rather than temperature of the object when we touch it. Students were asked more questions about sensation, heat transfer and temperature. For example, *When our clothes become wet in the rain, we become cool. So do you think the clothes become cold? Or the rate of heat transfer increased?*

This type of questions will make students that the newly constructed concept is fruitful (agree with the last stage of Postner's et al.(1982) conceptual change model). The same quantitative problems that were solved in control group also solved for students in experimental group.

RESULTS

To investigate the effect of treatment difference on the dependent variable and control the students' previous learning with respect to heat and temperature concepts, all of the subjects were administered TCE at the beginning of instruction. Data related to pre- and post-test is presented in Table-1. It was found that there was no significant difference between CCI group and TPI group in terms of understanding related to heat and temperature concepts ($t=0.89$, $df=80$; $p>0.05$) before the treatment.

Table 1: Means (M) and Standard Deviations (SD) of pre- and post- test results of Thermal Concepts Evaluation test (TCE) of experimental (CCI) and control (TPI) group.

		PRE TCE		**POST TCE**	
Group	N	M	SD	M	SD
Experimentanl (CCI)	42	9.02	2.82	17.26	2.70
Control (TPI)	40	8.48	2.78	11.45	2.48

After treatment, the effects of two modes of instructions on students' understanding of heat and temperature concepts was determined with analyses of covariances (ANCOVA) by controlling the effect of pre TCE scores as a covariate. The summary of analysis was given in Table-2. The analysis showed that the post-test mean scores of CCI group and TPI group with respect to understanding heat and temperature concepts were significantly different. Mean scores of CCI group (17.26) were significantly higher than that of TCI group (11.45).

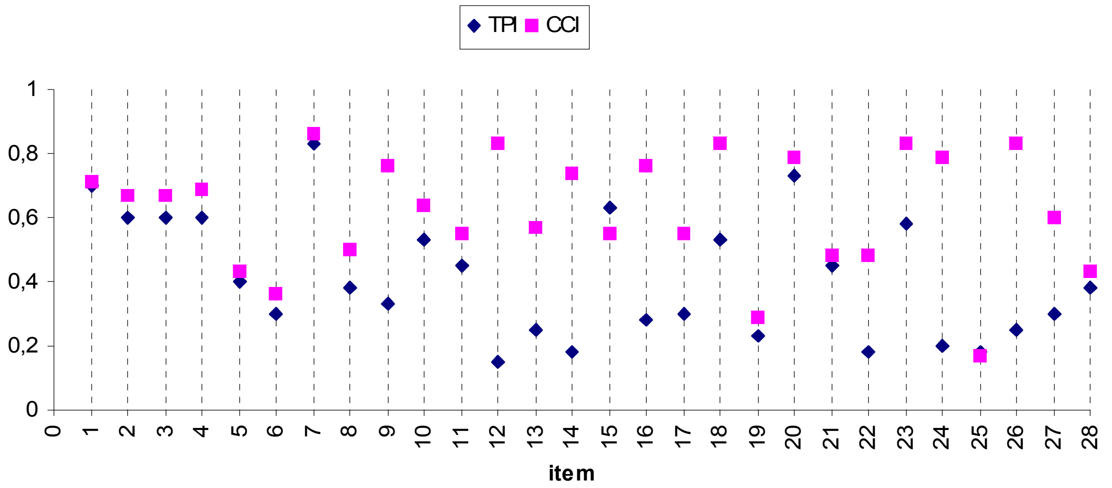
Table-2: ANCOVA Summary (Group vs. Achievement)

Source	**Sum of squares**	**df**	**Mean square**	**F**	**p**
Covariate (Pre TCE)	117.79	1	117.79	24.11	0.00*
Treatment	472.62	1	472.62	96.72	0.00*
Gender	6.77	1	6.77	1.39	0.243
Treatment * Gender	30.61	1	30.61	6.26	0.014*
Error	376.27	77	4.89		

* $p < 0.05$

Figure 2 displays the proportions of correct responses to questions in the post-test. As it can be seen from the figure, responses of the two groups were different on some items at the post TCE.

Figure 2 Proportions of Correct Responses in the TCE Post-test of TPI group and CCI group.



The two group responses approximately same on some items. Especially, proportions of correct responses for the first seven questions were about same and considerably high in five questions for the two groups. When these questions were investigated, they were numerical questions. For example, in the first question the temperature of ice cubes stored in a refrigerator's freezer compartment were asked. The highest correct proportion was question numbered 7. This question is a classical mix problem, e.g., the question asked temperature of the mixture when two cups of water at different temperature were mixed. These types of problems were solved in both groups while teaching heat and temperature unit. On the other hand, correct proportions of this question were more than 0.72 in the pre test.

Correct proportion for question 19 was very low for both groups. The question asked why pressure cooker cooks faster than a normal saucepan. It was not known that if a student did not know (a) pressurized water boils above 100 ^{o}C or (b) soup at high temperature cooks faster. Another question (numbered 25) asked whether there was a limit for lowest temperature. Although it was mentioned that -273 ^{o}C was the lowest minimum temperature during the lecture, neither students remind this nor students understand what is asked with this question. Since the question does not directly ask the lowest possible temperature, students may fail to answer correctly this question.

About half of the students in the control group did not know the scientific reason for wearing wool cloth on winter. More than 30% of the students in control group relay that wool generates heat. The same difficulty was previously stated by Duit ve Treagust (1998).

Figure 2 showed that there was striking differences between experimental and control groups in favour of the experimental group on several items. When investigated it was ween that, these items probed those alternative conceptions which attempted to change by cognitive conflict with experiments. For example, the concept of “objects that are at the same environment have the same temperature” was probed by 14, 16, and 24. More students in experimental group gave correct answer to these questions than students in control group. In question 12, the content of the bubbles in the boiling water were asked. 83% of the students in experimental group correctly answered this question, while only 15% of the students in the control group gave correct answer. The reason may be that, in experimental group, while doing an experiment where water was boiled, students were asked what the bubbles were. Likewise, Luera, Otto, & Zitzewitz (2005) found that most of the students failed to give correct answer for this question in conceptual change teaching medium.

Students did not recognize that objects must be wrapped by wool material for keeping as cold as possible in relatively warm environment. More than half of the students both in experimental and control group still thought that objects should be wrapped by aluminium foil to remain cool for a time. Lewis and Linn (2003) reported that scientist also had difficulties about the insulation properties of wool and aluminium foil.

As it can be seen from Table 2, the gender difference was not a significant effect on achievement. On the other hand, the interaction between treatment and gender difference significantly contributed to students' understanding of heat and temperature concepts.

Multiple regression analyses was used to analyse the contribution of previous understanding, treatments, gender difference of students, and the interaction between treatment and gender to the variation in improving students’ understanding of heat and temperature. Table 3 represents the summary table for the regression of achievement related to heat and temperature concepts on gender, treatment, and interaction between gender and treatment.

Table 3. Summary Table of Regression of Achievement Related to Heat and Temperature Concepts on Pre-TCE, Gender, Treatment and Interaction between Gender and Treatment

Dependent Variable	Predictor Variables	B	Std. Error	t	p
Achievement R^2=0.69	Pre-TCE	0.44	0.09	4.91	0.00*
	Treatment	3.87	0.87	4.47	0.00*
	Gender	-0.69	0.79	-0.89	0.38
	Interaction	2.63	1.05	2.5	0.01*
	Constant	8.26	1.04	7.94	0.00

* $p < 0.05$

The F value for the full regression model was significant ($F=43.37$, $p < 0.00$). The four predictor variables (pre-TCE, treatment, gender, and interaction) together accounted for 69.3%

of the variance in achievement related to heat and temperature concepts. In addition, pre-TCE, treatment and interaction between treatment and gender each made a significant contribution to the variation in achievement. But, gender did not make a significant contribution to the variation. Similar result was found by Başer (1996).

DISCUSSION AND IMPLICATIONS

This study explored the effect of instruction based on cognitive conflict to facilitate conceptual change in heat and temperature concepts. Physics education studies on thermodynamics showed that students had many alternative conceptions and difficulties related to heat and temperature concepts (e.g, Leura, Otto & Zewitz, 2005; Güneş & Gülçiçek, 2003; Yeo & Zadnik, 2001). Adults and scientist as well has alternative conceptions related to heat and temperature concepts (e.g., Leura, Otto and Zewitz, 2005; Lewis ve Linn, 2003; Cailot ve Xuan, 1993). Preliminary studies of this paper also showed that preservice teachers had similar alternative conceptions and difficulties.

Cognitive conflict based physics instruction improved students understanding of heat and temperature concepts more than traditional physics instruction. Although both type of instruction provided gain in achievement related to heat and temperature, the gain in experimental group was statistically higher than in control group. The big difference in normalized gain obtained by cognitive conflict based physics instruction (<g>exp=42.7%) relative to traditional physics instruction (<g>cont=14.7%) can be attributed to the following properties: (1) activation of students' alternative conceptions, (2) presentation a situation that could not be explained with existing concepts, (3) creation of cognitive conflict with this anomalous situation, (4) the need for other conception(s) to explain this anomalous situation, (5) active construction of students' own knowledge, (6) students interaction with each other to share their ideas about the anomalous situation and it's possible solution, and (7) the knew conception is helpful to solve similar problems that may be encountered in the future. These are in agreement with themes of both constructivism and conceptual change theory posed by Posner et al. (1982). As shown from this study, conceptual change based on cognitive conflict is still a powerful instruction to teach physics concept (Duit, 2002). Additionally, taking account students' difficulties in designing the lecture fosters conceptual change (Jones et al., 2000). The students were avoided to think what they liked, during the discussion sessions in experimental group (Harrison, Grayson, & Treagust, 1999). The difference between their alternative conceptions and scientist' were explained.

In one question students were asked why pressure cooker cooks faster than a normal saucepan. To answer this question, students should know (a) pressurized water boils above 100^{o}C and (b) soup at high temperature cooks faster. The second conception was not in the objectives of the course given to the both experimental and control group students. It was not known that why students gave incorrect answer for this question. Another explanation for the bad achievement in this question was given by Leura, Otto, & Zewitz (2005). They concluded that a student who never cooked with pressurized cooker may not be give correct answer for this question. Therefore, this question needs to be modified to fit one of the objectives for thermodynamics coursed.

Some of the alternative conceptions were still retained by students in experimental group. For example, although many students in experimental group understood that objects needed to be wrapped with wool to keep them as hot as hot possible, they failed to understand that objects needed to be wrapped with wool to keep them as cold as possible. This sowed that accomplishing conceptual change is not an easy task if the difficulty arises from the interpretation of daily life events (Campanario, 2002). When asked to students in an informal context, most of them said that everyone uses aluminium foil to keep hot cake, toast, hamburger, etc. In such cases, students relayed their daily life observations rather than what they learned within the course.

Although, gender did not account for a significant portion of the variation in achievement of heat and temperature concepts, the interaction between gender and treatment did. Similar findings were obtained by Başer (1996). This interaction could come from the gender difference in the group who utilized the cognitive conflict based instruction. When ANOVA statistics were run on normalized gain <g> female students were significantly gained more than male students in experimental group. Hake (1988) argues that the normalized gain is a meaningful measure of how well a course teaches physics to students. So it is more reliable to investigate the gain score to discuss what have learned from a physics course rather than post-test itself. It can be concluded that cognitive conflict based physics instruction was superior for females. In the directions of ECT it was stated that “think of a group of friends in a kitchen.” These may be increased girls’ attention to the thermodynamics course. This conclusion requires validation with a future research.

The final remark is that, as supposed by the result of this study, it is required to make radical changes in the design of physics instruction if we want to increase students’ conceptual understanding (Meltzer, 2004).

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APPENDIX A: QUESTIONS APPENDED TO TCE

1. Ali wants to keep the cola can taken from the refrigerator as cold as possible when going to picnic. Which one of the following material will you suggest to Ali for wrapping the cola can?

A) Aluminium foil

b) Plastic film

c) Cotton material

d) Wool material

2. Ayşe will bring the newly toasted hamburger to his sun in the school. Which of the following material will you suggest to wrap the hamburger, if she wants it be as hot as possible?

A) Aluminium foil

b) Plastic film

c) Cotton material

d) Wool material

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