Students' Cognitive Conflict Levels by Provided Quantitative Demonstration and Qualitative Demonstration

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The purpose of this study was to understand middle school students' cognitive conflict levels when they were confronted with anomalous situations. The anomalous situations were created by two different methods; quantitative and qualitative demonstrations. In this research, two physics contexts, mechanics and electricity were used. In each context, two test items, one for quantitative demonstration and the other for qualitative demonstration were given to the students after a pretest. To measure the cognitive conflict levels, a Cognitive Conflict Levels Test (CCLT) developed by Lee et al. (1999) was used.

The quantitative demonstration group showed higher cognitive conflict level than the qualitative group did in the electricity context; however, there was no significant difference in the mechanics context.

I. INTRODUCTION

In the constructivists' view, students' conceptual changes are influenced by their preconceptions. Students have their own ideas about phenomena of interest to science and those ideas usually differ from scientists' current views. Recent researchers have proposed cognitive conflicts as an important factor to promote students' conceptual change. Some researchers have considered cognitive conflict as one of the conditions in conceptual change and proposed theoretical models for conceptual change (Ponser et al., 1982[1]; Hashweh, 1986[2]; Kwon, 1989[3]/1997[4]).

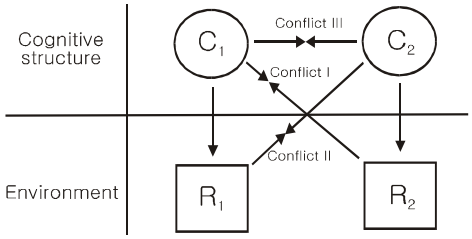


Figure 1 Kwon's cognitive conflict model(Kwon, 1989)

In this study, we used Kown's model (1989) [3] to create cognitive conflict. Kwon has emphasized the role of cognitive conflict as a central condition for conceptual change. Kwon modified Hashweh's diagram (Hashweh, 1986)[2] as in Figure 1. He proposed three different conflicts in one's mind. In upper section of Figure 1 illustrates cognitive structures and the lower section are stimuli from the environment. C_1 represents students' preconceptions which would most likely be a misconception in a typical classroom situation. C_2 represents the scientific concept to be learned. R1 represents an environment that could be well explained by C_1, while R_2 is an environment explained only by C_2. R_1 and R_2 do not represent only one single external phenomenon but the entire set of observations and stimuli from one's environment. The type of cognitive conflict represented in Piaget's thinking is conflict between C_1 and R_2 (labeled Conflict1 in Figure 1). On the other hand, the type of cognitive conflict represented by Hashweh's thinking is between C_1 and C_2 (labeled Conflict 3). However, in this diagram one may also recognize another kind of cognitive conflict between C_2 and R_1. Kwon proposed this as another kind of cognitive conflict (Conflict 2). In here, R_2 is an anomalous data or demonstration. Because R_2 is cause of the Conflict 1, the type of R_2 is important.

In this study, we measured students' cognitive levels by the provided quantitative demonstration and qualitative demonstration. Student observed a R_2 demonstration, contrary to his/her preconception, presented by the teacher. R_2 is anomalous situation to the student. We classified the demonstration, depending on whether there was a scale or not in the demonstration, as quantitative and qualitative. First, we examined cognitive conflict levels caused by provided demonstrations. Second, we measured the cognitive conflict levels of students who changed

their preconceptions with those who adhere to their preconceptions. Third, we investigated correlation between cognitive conflict level and belief level in preconception.

II. RESEARCH CONTEXT

The pretest was tested to 297 students from 8 classes (2 classes for each group) of a middle school in Korea. Among 297, 228 students were selected because they had incorrect answer in the pretest. The number of subjects were fellowed; in a mechanics context, 60 for the quantitative demonstration group, 60 for the qualitative demonstration group; in an electricity context, 46 for the quantitative demonstration group, 62 for qualitative demonstration group. The topics of the test items in mechanics were action-reaction in a spring and action-reaction between two magnets. Test items in electricity included two bulbs in series. Data on students' conceptions were collected through a written test. For each item, the students were asked to explanation of their thinking. A demonstration was presented after the pretest. The context of each item is shown in the Table 1. Two kinds of anomalous situations were presented. One was a quantitative demonstration with scale, the other was a qualitative demonstration without scale.

Cognitive conflict levels were measured after the demonstration. To measure the cognitive conflict levels, Cognitive Conflict Levels Test (CCLT) developed by Lee et al.(1999)[5] was used.

The CCLT includes the preliminary stage and the cognitive conflict stage. The components in the preliminary stage are belief in a preconception and belief in the genuineness of anomalous situation. The components in the cognitive conflict stage are followed: (1) recognition of anomalous situation, (2) interest, (3) anxiety, and (4) cognitive reappraisal of the situation. Each component of cognitive conflict stage consists of three test items. All items were on a 5-stage Likert scale (0 = not at all true of me, 4 = very true of me). Cognitive conflict level was rated from 0 to 4 according to the degree of a student's respond to each item. The total score of cognitive conflict level is 48. The content validity coefficient of CCLT was 0.93.

III. RESULTS

1. Cognitive Conflict levels by type of demonstration

Table 2 gives cognitive conflict levels by type of demonstration. A quantitative demonstration group showed higher level of cognitive conflict than the qualitative group in the electricity context. The factors, 'Recognition of anomalous situation', 'Anxiety' and 'Cognitive reappraisal of the situation' in quantitative group were higher cognitive conflict levels. However, there was no significant difference in the mechanics context.

Table 1. The Types of Demonstration

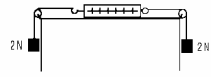
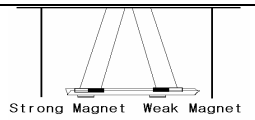
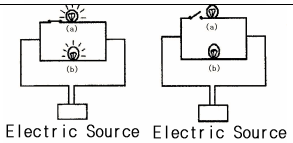
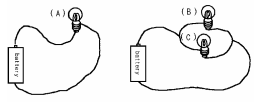
	Classification	Types of Demonstrations	Note
Mechanics	Quantitative Demonstration		Action-reaction in a spring (students observed scale on a spring scale)
	Qualitative Demonstration		Action-reaction between two magnets (students observed pushed distance of magnets)
Electricity	Quantitative Demonstration		Electric bulbs in parallel problem (students observed scale on an illuminometer)
	Qualitative Demonstration		Electric bulbs in parallel problem (students observed brightness of bulbs)

Table 2. Cognitive Conflict levels by the types of demonstration

	Mechanics		Electricity	
	Quantitative (n=60)	Qualitative (n=60)	Quantitative (n=46)	Qualitative (n=62)
Recognition	8.63	7.88	8.00	5.90 *
Interest	7.43	7.16	7.41	7.08
Anxiety	5.41	4.70	5.72	3.71*
Cognitive Reappraisal	8.18	7.80	7.82	7.05 *
Total Score	29.67	27.55	28.96	23.74 *

*** p <.05**

2. Comparison of cognitive conflict levels between students who change of their preconceptions and students who adhere to their preconceptions.

After we presented the demonstration, we asked to students whether their preconceptions were change or not.

In the quantitative group, all students changed their preconceptions. In the qualitative group, many students didn't change their preconceptions. Even though there was no difference in brightness of two bulbs, they explained the provided demonstration with their preconceptions.

Table 3 gives the comparison of cognitive conflict levels between the students who change of their preconceptions and the students who adhere to their preconceptions. Among the 60 students, 50 changed their conceptions after the qualitative demonstration in the mechanics context. Among the 62 students, 24 changed their preconceptions after the qualitative demonstration in the electricity context. The students who changed their preconceptions showed higher levels of cognitive conflict than the students who adhered to their preconceptions when the qualitative demonstration was provided.

3. Correlation between cognitive conflict levels and levels of belief in preconceptions.

We measured belief in preconceptions by using the preliminary of the CCLT.

Table 4 showed the correlation between cognitive conflict levels and belief levels in preconceptions. The correlation was 0.4064 for the quantitative demonstration group in the mechanics context. In case of the electricity context was 0.5757. The correlation for the quantitative demonstration group in which changed their preconception was showed positive correlation. However, the correlation was not significant in the qualitative demonstration group.

IV. CONCLUSION

In this study, first, we examined cognitive conflict levels by use of the provided demonstrations. The quantitative demonstration group showed higher cognitive conflict levels than the qualitative group in the electricity context; however, there was not significant difference in the mechanics context. Many researchers have examined the effet of cognitive conflict experimentally. (Hawson & Haswon, 1984[6]; Niaz, 1995[7]; Druyan, 1997[8]) Assuming that cognitive conflict provides positive effect on conceptual change, the quantitative demonstration is more effective than the qualitative demonstration for conceptual change in the

Table 3. The cognitive conflict levels of students who change of their preconceptions and students who adhere to their preconceptions

	Mechanics				Electricity			
	Quantitative Demonstration		Qualitative Demonstration		Quantitative Demonstration		Qualitative Demonstration	
	Change	Adhere	Change	Adhere	Change	Adhere	Change	Adhere
Recognition	8.63	-	8.66	4.00*	8.00	-	8.88	4.03 *
Interest	7.43	-	7.36	6.20	7.41	-	7.46	6.84
Anxiety	5.41	-	5.12	2.60*	5.72	-	5.58	2.53 *
Cognitive Reappraisal	8.18	-	8.16	6.00*	7.82	-	8.67	6.03 *
Total Score of CCLT	29.67	-	29.30	18.80*	28.96	-	30.58	19.42 *

*** p <.05**

Table 4. Correlation between cognitive conflict levels and belief levels in preconceptions

	Mechanics				Electricity			
	Quantitative Demonstration		Qualitative Demonstration		Quantitative Demonstration		Qualitative Demonstration	
	Change of Preconception	Adhere to Preconception	Change of Preconception	Adhere to Preconception	Change of Preconception	Adhere to Preconception	Change of Preconception	Adhere to Preconception
Recognition	.4955	-	.0903	.3043	.5716	-	.4721	-.2103
Interest	.3278	-	.2575	.0184	.5231	-	.2559	.1304
Anxiety	.0715	-	-.1297	-.2215	.3066	-	-.1573	-.1354
Cognitive Reappraisal	.3840	-	-.1471	-.1260	.6028	-	.1596	.0773
Total Score of CCLT	.4064	-	.0152	-.0688	.5757	-	.1845	-.0333

electricity context. Second, we compared cognitive conflict levels between students who change of their preconceptions and the students who adhere to their preconceptions. The students who changed their preconceptions showed higher cognitive conflict levels than the students who adhered to their preconceptions when the qualitative demonstration was provided. The 'Interest' factor of the CCLT was no significant between the quantitative demonstration group and qualitative demonstration group as in Table3. That is, students have interest in observing the demonstration itself. Third, we investigated the correlation between cognitive conflict levels and belief levels in the preconceptions. There was a positive correlation in the quantitative demonstration group. However, there was no significant in the qualitative demonstration group. The students having strong belief in their preconceptions had experienced more cognitive conflict though the provided quantitative demonstration. That is, the quantitative demonstration is more effective in creating cognitive conflict for the students with strong beliefs in their preconceptions. Because all students who observed the quantitative demonstration had changed their preconceptions, the quantitative demonstration was more effective in conceptual change.

We estimated the levels of cognitive conflict quantitatively by provided types of demonstration. We should be research the relationship between cognitive conflict levels and conceptual change by the provided types of demonstration.

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