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The effect of using v-diagrams in science and technology laboratory teaching on preservice teachers' critical thinking dispositions

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Abstract

The aim of this study was to investigate the effects of V-diagrams in Science and Technology laboratory teaching on preservice teachers' critical thinking dispositions. In accordance with the purpose, matching only pretest-posttest control group design was used. The study was carried out with 60 teacher candidates enrolled in the Elementary Teacher Program in a state university in Turkey. V-diagrams were used in experimental group, whereas the same teaching activities weren't implemented in control group. Adapted Turkish version of California critical thinking disposition test (CCTDI-T) which includes six dimensions was used as pre and posttest for determining preservice teachers' critical thinking disposition levels. In the analysis of the data, frequencies, means, and after verifying its assumptions several ANCOVA analysis were used. The significant difference was observed only in the fourth dimension (self-confidence) of the scale in favor of experimental group. This finding showed that using V-diagrams and routine teaching activities have different effects on preservice teachers' critical thinking dispositions in science and technology laboratory. In line with the research results, the effect of using of V-diagrams were discussed regarding each dimension of the CCTDI-T and several recommendations were offered accordingly.

Keywords: V-diagram, critical thinking disposition, science education

1. Introduction

One of the primary purposes of modern education is to explore individuals' thinking processes in order to help them to develop their thinking skills. When individuals try to understand events and phenomena around them, they use thinking processes such as querying, analyzing and discussing. Thinking is one of the most important human ability that makes him/her "human" as noted by Aristotle. Therefore, thinking has to be developed not only quantitatively but also qualitatively (Gündoğdu, 2009). Teacher candidates, who will shape our future, are to be prone to develop their own critical and creative thinking skills and contribute students for gaining these skills.

Literature foundations about critical thinking are based on John Dewey. He describes critical thinking skill as attentive and continual consideration and revision of knowledge or belief in the light of the evidences supported by arguments of this knowledge and belief (as cited in Gündoğdu, 2009). Then, literature of critical thinking skills has been developed by different researchers through examinations in different dimensions. While Enis (1985) discussed critical thinking with three structures; judgment, developing of knowledge and inquiry, Watson and Glaser (as cited in Şensoy & Yıldırım, 2011) regarded it as an ability of specifying values and attitudes. Critical thinking is defined as wanting clues before accepting other people's opinions and providing clues to force other people's reasoning (Hudgins, Riesenmy, Ebel, & Edelman, 1989). It is not an inherited attribute transferred from parents; it is a high stage thinking skill and it can be taught or developed by using feasible learning strategies and benefiting from metacognitive thinking tools which encourage students to think critically (Gündoğdu, 2009; Yıldırım & Şensoy, 2011). It is known that, individuals who have critical thinking skills can't always reflect this skill in their own daily

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life, and for this reason critical thinking skills can be associated with disposition (Halpern, 1988; Seferoğlu & Akbıyık, 2006). The disposition of critical thinking skill can be described as demanding, tending or being prone to critical thinking (Şengül & Üstündağ, 2009).

There are two basic approaches about how to think critically in schools. These are "content based" and "skill based" critical thinking programs (Aybek, 2006). According to Ruggiero (1988), critical thinking should be integrated in the education program. But this expression doesn't mean changing the course content or using foreign new concepts. Elements of critical thinking can be thought through different learning experiences (Şahinel 2002). According to the view of Lipman (1988) and Ennis (1991), which support skill based critical thinking program, if, critical thinking is thought in a content-based form, the focus will be on the content of the class and this will rule out the development of the students' critical thinking skills and limit this kind of skills as well. In this research, V-diagram was used with content based critical thinking approach.

V-diagram is one of the effective tools that provide meaningful learning and developing metacognitive skills (Novak, 1990; Novak & Gowin, 1984; Passmore, 1998). V-diagram was developed by Bob Gowin in 1970. It is a metacognitive thinking tool that helps people understands the nature of knowledge and construction processes of knowledge (Novak & Gowin, 1984). In other words, V-diagram is a tool which can be used in educational environments to foster students' thinking skills and force them to use these thinking skills as well as constructing positive attitudes for deeper thinking.

V-diagram works as "thinking" and "doing" (Gowin & Alvarez, 2005; Novak & Gowin, 1984). It starts with drawing a big V. It includes writing conceptual knowledge already known by students on the left side of the V and experiment, whereas project or steps of problem statement on the other side. A focus question or questions, which is/are regarded as starting point of the process is/are located in the middle of the diagram. The focus question/questions is/are an active dynamic bridge between the knowledge already known and estimations that are acquired from actions. Methodological knowledge which is described as "doing" is placed on the right side of the diagram. When the students carried out their action about focus question, they record data during the action and transform them to a table, graph etc. And then they write their knowledge and experiment claims about the action (Novak & Gowin, 1984). In the literature there are several kinds of V-diagrams (Afamasaga-Fuatai', 2004; Luft et al. 2001; Meriç & Nakipoğlu, 2000; Thiessen, 1993).

Ocak (2007) explained the critical thinking process as observations, inferences, assumptions, discussions and comparisons of opposite views. When V-diagram and critical thinking processes are compared, it can be said that the diagram comprises these processes. It is thought that, V-diagram is a metacognitive thinking tool to encourage preservice teachers to use critical thinking skills. Therefore, this study was planned to determine the effect of using V-diagram toward critical thinking disposition of elementary teachers' candidates in Ankara.

2. Method

The matching-only pretest-posttest control group design which is one of the quasi-experimental designs is used in our research (see Table 1). The letter M in this design means that the subjects in each group have been matched (on certain variables) but they are not randomly assigned to the groups (Fraenkel & Wallen, 2006).

Table 1. Research design

		O	**X**	**O**
Experimental Group	M	Pretest: Critical Thinking Dispositions Inventory	Teaching activities based on V-diagrams	Posttest: Critical Thinking Dispositions Inventory
		O	**C**	**O**
Control Group	M	Pretest: Critical Thinking Dispositions Inventory	Routine teaching activities	Posttest: Critical Thinking Dispositions Inventory

2.1. Problem Statement

The research question of this study is "Are there any effects of the use of V-diagrams on preservice teachers' critical thinking dispositions in science and technology laboratory?"

2.2. Participants

This study was conducted on a state university, located in Ankara, during spring semester of 2010-2011 academic years. Research participants were 60 second year preservice teachers of the elementary teacher education program. Thirty (21 female, 9 male) of these students were in control group, whereas remaining 30 (22 female, 8 male) were in experiment group. The ages of the preservice teachers ranged from 20 to 23.

2.3. Instruments

In order to determine critical thinking disposition levels, California Critical Thinking Dispositions Inventory (CCTDI) was used. The inventory includes 75 items in the seven sub dimensions of "seeking the truth", "open mindedness", "analyticity", "inquisitiveness", "systematicity", "self confidence", and "maturity". The CCTDI was translated and adapted to Turkish by Kökdemir in 2003. As a result of the factor analysis and several other analyses, not only 24 items of the CCTDI were deleted, but also "open mindedness" and "maturity" scales were decided to be merged. This new Turkish version of the inventory (CCTDI-T) was found to have sufficient content validity evidences by the professionals in the field. The CCTDI-T included six scales, 22 negative items, and a total of 51 items (see Table 2). The items in the CCTDI-T designed to be rated on a six-point Likert type response format (from strongly agree to strongly disagree). The choice of "strongly agree" was regarded as six point whereas "strongly disagree" as one points. The Cronbach alpha reliability coefficient of the CCTDI-T was found 0.88 by Kökdemir in 2003. This research's pre and posttest Cronbach values were found 0.86 and 0.84 respectively.

Table 2 Items in each dimension of the CCTDI-T

Dimensions	Number of items	Items
1. Analyticity	10	2-3-12-13-16-17-24-26-37-40
2. Open Mindedness	12	5-7-15-18-22-33-36-41-43-45-47-50
3. Inquisitiveness	9	1-8-30-31-32-34-38-42-46
4. Self Confidence	7	14-29-35-39-44-48-51
5. Truth Seeking	7	6-11-20-25-27-28-49
6. Systematicity	6	4-9-10-19-21-23

2.4. Procedure

The CCTDI-T was applied as a pretest to 60 preservice elementary teachers. In order to determine experimental process effects, the CCTDI-T was applied again as a posttest after four weeks (eight lesson periods). V-diagrams based laboratory teaching was used in experimental group. In the beginning of the implementation, the researcher explained what V-diagram is and how V-diagrams are prepared. After students were informed about V-diagrams, question development phase was done in order to determine their focus questions and "why" and "how" question forms which require scientific explanations, were asked every preservice teacher and large group discussions were done on the structured questions.

In the second stage of the research implementation process, small groups of 3-4 preservice teachers were formed. Two pre structured focus questions were shown as examples by the researcher for the preservice teachers to prepare V-diagram steps. The focus questions were "How the non-evergreen trees photosynthesize in winter?" and "How do different colored trees photosynthesize?"

V-diagrams prepared by the participants were discussed in whole group. In the third stage, the researcher asked the students to form focus questions according to their interest. All formed focus questions are as follows:

1. How can we prevent darkening when we cut apple and potato?
2. Why do we see the same side of the moon?
3. How does position of olive oil change in different liquids?
4. What are the factors that effect mold formation?
5. Why does baking powder puff of the cake?
6. What purpose do the tails of animals serve?
7. How do different colors absorb light?
8. Why does substance sink or float in the water?
9. What are the factors that affect the brightness of light bulb in basic electric circuit?

V-diagrams were structured with focus questions by preservice teachers. At the end of the research, knowledge and experimental claims related to the answers of focus questions' in structured V-diagrams were inquired through a large group discussion. The control group wasn't manipulated and carried out the routine teaching activities. And in the control group, closed-ended and open-ended experiment activities and outdoor education activities were used by teacher. Large and small group discussions were included.

2.5. Data Analysis

After experimental process, all data related to 51 items were coded from one to six in a SPSS data file. Moreover, all negative items (05-06-09-11-15-18-19-20-21-22-23-25-27-28-33-36-41-43-45-47-49-50) in the CCTDI-T were recoded reversibly (six to one). Dimension scores were computed by considering Table 2 and summing up each item scores in the corresponding dimension. Since the numbers of items in each dimension of the CCTDI-T were not the same, the total scores computed for the dimensions were divided by the number of items in each dimension. These standard scores ranging between one and six were used to compare dimensions with each other. Additionally, groups' frequency and mean scores were calculated for each dimension of the CCTDI-T as a descriptive statistic. Moreover, several analyses of covariance were used as an inferential statistic.

3. Findings and Results

3.1. Descriptive Statistics

Table 3 shows preservice teachers' pretest, posttest, and gain scores' arithmetic means for each group related to each dimension of the CCTDI-T. As seen from Table 3, preservice teachers' pretest mean scores (maximum 6) were over 4 (referring positive disposition) in four of the dimensions of the CCTDI-T. Additionally, experiment group's total critical thinking disposition score was 4.224 and control groups' was 4.093 in the pretest. Experimental group's critical thinking dispositions were higher than control group in both total pretest mean score and in four dimensions of the CCTDI-T. However, it is understood that both of the groups' total critical thinking dispositions were slightly decreased ($X_{experiment}$= -0.039, $X_{control}$= -0.106) after the treatment. When each dimension's gain mean scores were compared, it was seen that both groups gain scores were positive in three dimensions (analyticity, inquisitiveness, self confidence) and negative in two dimensions (open mindedness, truth seeking). The highest gain mean difference between groups (in favor of experimental group) was occurred in the dimension of "self confidence".

Table 3. Standardized mean scores for each dimension of the CCTDI-T

Dimensions	Groups	n	Pretest Mean	Posttest Mean	Gain Mean
1. Analyticity	Experiment	30	4.673	4.710	0.037
	Control	30	4.451	4.459	0.008
2. Open Mindedness	Experiment	30	4.361	3.958	-0.403
	Control	30	4.243	3.814	-0.429
3. Inquisitiveness	Experiment	30	4.441	4.535	0.094
	Control	30	4.193	4.320	0.127
4. Self Confidence	Experiment	30	3.900	4.383	0.483
	Control	30	4.019	4.125	0.106
5. Truth Seeking	Experiment	30	3.547	3.290	-0.257
	Control	30	3.148	3.033	-0.115
6. Systematicity	Experiment	30	4.044	4.048	0.004
	Control	30	4.236	3.998	-0.238
Total	Experiment	30	4.224	4.185	-0.039
	Control	30	4.093	3.987	-0.106

3.2. Determination of the Covariates

The researchers predetermined two independent variables (pretest and gender) as possible confounding factors of this study. However, the measuring tool used in this study had six dimensions. Therefore pretest variable were divided into six separate independent variables and these new variables were named as preCCTDI-T1, preCCTDI-T2, preCCTDI-T3, preCCTDI-T4, preCCTDI-T5, and preCCTDI-T6. Likewise, the dependent variable of the study which was formed by preservice teachers' posttest scores taken from the CCTDI-T were divided into six and tagged

as postCCTDI-T1, postCCTDI-T2, postCCTDI-T3, postCCTDI-T4, postCCTDI-T5, and postCCTDI-T6. All these seven independent variables were correlated with six dependent variables. Table 4 shows the correlation coefficients related to these variables. All bivarite correlations of the variable gender with dependent variables were not significant. Therefore, this variable was excluded from rest of the study. But, pretest scores of each dimension were significantly correlated with post scores. Therefore, they were taken as covariates for each inferential analysis conducted according to dimensions of the CCTDI-T.

Table 4. Significance test of correlations between dependent variables and independent variables

Variables	postCCTDI-T1	postCCTDI-T2	postCCTDI-T3	postCCTDI-T4	postCCTDI-T5	postCCTDI-T6
preCCTDI-T1	.536**	.285	.484**	.260	-.034	.271
preCCTDI-T2	-.039	.638**	.068	-.046	.474**	.352
preCCTDI-T3	.423*	.291	.673**	.537**	.047	.433*
preCCTDI-T4	.398*	-.335	.672**	.646**	-.289	.203
preCCTDI-T5	-.023	.462*	.078	.038	.526**	.559**
preCCTDI-T6	.075	.564**	.101	.038	.287	.618**
Gender	.797	.716	.678	.66	.047	.040

* Significant at the .05 level (two-tailed) ** Significant at the .01 level (two-tailed)

3.3. Inferential Statistics

In this study, seven ANCOVA (for each dimension plus total) were conducted. For each ANCOVA, all of its assumptions were controlled and verified before using them. For normality and equivalence of variances assumptions, Shapiro-Wilks and Levene tests were used respectively. Moreover, full factorial two-way ANOVA was used to assess homogeneity-of-slopes assumption.

The only statistically significant result is shown in Table 5. Accordingly, a significant difference was found only in the fourth dimension of the CCTDI-T ($(F\ 1,57) = 4.322$, $p<.05$). In other words, there was a significant mean difference between experimental and control groups' mean scores only in fourth dimension of the CCTDI-T when pretest scores controlled. No differences were found in other dimensions. It is determined that learning environments which were based on V-diagram and which were not based on V-diagram had different effects on enhancing critical thinking dispositions of preservice teachers.

Table 5. ANCOVA results related to fourth dimension of the CCTDI-T

Source	SS	df	F	Sig.	Eta squared
preCCTDI-T4	294.702	1	17.150	.000	.231
Method	74.278	1	4.322	.042	.070
Error	979.506	57			
Total	54519.021	60			

4. Conclusions and Recommendations

In this study, having a content based approach, the effect of using V-diagram upon preservice teachers' critical thinking dispositions was investigated. For this purpose, applications were executed in laboratory and it is assumed that participants were not affected from each other.

With the scale used in this study to assess preservice teachers' critical thinking dispositions, it was found that there was a statistically significant difference only in "self-confidence" dimension. In "open mindedness" and "truth seeking", scores of the participants decreased in both groups. In "systematicity" dimension, there was a small increase in experimental group scores, while control group scores were diminished.

It was determined that, pretest scores of preservice teachers in both experimental and control groups were over 4 points, except for the sub-dimension of "truth seeking". These participants' high beginning scores were thought to be a disadvantage for increasing their critical thinking dispositions even after the treatment. Since they were preservice teachers and their ages ranged from 20 to 23, this also can be factor in this resistance to change.

In the literature we didn't encounter a study about V-diagram's effect upon individuals' critical thinking dispositions. But in experimental studies, it can be seen that individuals' critical thinking dispositions increased with different applications (Akınoğlu, 2001; Hermann, 2002; Şahinel, 2001; Öner, 2009; Yeh, 2004). Aybek (2006) expressed in her study about effectiveness of content based approach and CORT 1 (Cognitive Research Truth) upon critical thinking abilities that teaching critical thinking abilities within a program is more effective. Additionally Beyer (1991) mentioned that developing critical thinking skills takes a long time and these skills can be acquired by the students who are exposed to long time education based on a thinking process. From this point of view, we think that the four week period of our study is a disadvantage. As a result, to determine individuals' critical thinking dispositions, long term studies with different methods and techniques are suggested to other researchers.

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