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Experimental Investigation of the Effects of Learning Environment and The Nature of Educational Program on the Outcome of Creativity Training*

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Abstract

The purpose of this study is to examine the effects of computer-based creativity training. Four groups of vocational high school students totaling 151 were used as experimental subjects. Two dimensions of treatment were designed. One treatment dimension is the use of computer medium in education: computer based vs. paper-pencil setting of education. The second treatment dimension is the method of creativity training: technique-oriented training program vs. factor-oriented training program. Both a pretest and a post-test were administered to all participated students. The tests were composed of a Creative Figural Test and a Creative Product Test. After the pretest 8 sessions of creative training were delivered as intended in the design of the experiment. The post-test was arranged a week after the completion of the training sessions. The results of the study include: First, all the 4 groups showed certain amount of improvements in their scores of Creative Figural Test, while no improvements was observed in the creative product test score. Second, the technique-oriented creativity training was more effective than the factor-oriented under the context of computer-based education, and the factor-oriented training was more effective in the paper-pencil setting. The results suggest that different pedagogical approaches should be employed for computer-based training as compared to the paper-pencil education.

Keyword : creativity training, pedagogical approaches, e-Learning, computer-based

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1. Introduction and Research Background

Social and economic environment of the 21st century exhibit the emergence of diverse streams of dramatic changes. These paradigmatic changes include at least two notable phenomena : explosive diffusion of information and communication technologies, and soaring importance of knowledge and creativity. The diffusion of information and communication technology is represented by the fast and widespread use of personal computers, Internet, and mobile communication devices. For example, over 50% of Korean population is Internet users and about 9.2 households out of 100 have high-speed Internet access such as ADSL and Cable TV Network (OECD, 2000).

1.1 Computer-based Training and e-Learning

The widespread use of computer and network technology and its pedagogical application has opened up computer-based e-learning market. Computer-based learning is basically a type of distance learning, where computer medium is used as a training delivery mechanism. Here, technological intervention is involved between trainer/teacher and trainee/student in the educational interaction. Computer-based learning or on-line learning environment is considered to have several advantages compared to classroom-based or instructor-led off-line learning environment. For example, both synchronous and asynchronous delivery of education is possible, various multimedia and hyper-text educational material can be used, any-time any-where learning can be realized, and active participation of learners can be evoked using game-like role-playing scenario (Rosenberg, 2001). According to a report from OECD, e-learning is going to form one of the fastest growing industry through the forthcoming decade (OECD, 2000).

While analyses of the effectiveness of the use of computer-based environment have shown conflicting results, making more investigation to be remained, the use of computer medium and Internet is not an option any more. As most of the training institutions furnish Internet access environment and content sites, the use of e-learning has gone beyond the adoption decision (Owens, 1999 ; Ford and Jurewicz, 2001). Now, the question focuses on the level of the use of technological medium, the type of technological environment to be employed, and the method of training that fits the technological environment (Cao and Zhang, 2001).

1.2 Creativity in Management and Creativity Training

Today's economic trend exhibit a tendency that the importance of the value created or supported by information and knowledge increases rapidly. Given such shift in the sources of value added, creativity or the enhancement of it is gaining high focus of corporate and research attention. Although the relationship between organizational-level creativity and the level of individual creativity has not been fully established, the importance of creativity training to improve personal creativity or the outcome of creative thinking has been emphasized both in practice and in academia (Carr, 1994).

Although there are several definitions of creativity, two major criteria used for evaluating the level of creativity are commonly mentioned : novelty and appropriateness. Creativity is consid-

ered as an integrated construct (Amabile, 1983 ; Runco & Chand, 1995 ; Urban, 1991). Urban's (1991) components model of creativity emphasizes the importance of interactive structure among the problem, process, product, personality, and environment. Creativity can therefore be defined as the ability to make a novel and appropriate product via the interaction among the personality, cognition, problem and environment.

Various techniques designed to assist generating creative ideas have been suggested. These techniques include brainstorming, SCAMMPER, attribute listing, PMI, and synetics (Starko, 1995). Some of these strategies were originated and used in business context such as the development of new products. The usefulness of computer-based creativity evoking process was also examined. For example, Siau (1996) suggested that the advantage of electronic brainstorming over verbal brainstorming lies in its potential to overcome production blocking and evaluation apprehension, the two typical barriers observed in verbal brainstorming process.

2. Research Model and Experiment Design

The main purpose of this study is to examine the effects of computer-based creativity training. We attempted to analyze the effects of computer-supported environment as well as the effects of creativity training approaches. For this reason the research hypotheses were set as follows :

Hypothesis 1 : The creativity score will increase after the training sessions (That is, the scores of posttest will be higher than the scores of pretest in all experimental groups).

Hypothesis 2 : The level of creativity and training effects (the scores of creative figural test) will differ across the level of class achievement, type of educational setting (on-line vs. off-line), and training program type.

Hypothesis 3 : There will be correlations among achievement level, education type, and program type.

2.1 Experimental Treatment

Two dimensions of treatment were designed [Figure 1]. One of the dimensions is the learning environment. This dimension is operationalized as the use of computer medium in education, that is computer based vs. paper-pencil setting of education. The second treatment dimension is the

Education Type (environment)	Technique Oriented	Factor Oriented
Computer-based	Computer-based Technique-oriented Training	Computer-based Factor-oriented Training
Paper-Pencil	Paper-Pencil Technique-oriented Training	Paper-Pencil Factor-oriented Training

Training Program Type

[Figure 1] Design of the Experiment (2×2 Factorial)

method of creativity training. Training method is operationalized as the nature and contents of training program, that is technique-oriented training program and factor-oriented training program were employed and compared. We used the level of academic achievements as an intervening variable.

2.1.1 Computer-based vs. paper-pencil setting of education

Paper-pencil setting of education is the traditional learning environment used in normal classroom teaching. The researcher distributed program materials to the subjects, delivered the lecture to explain the contents, and provided answers to questions.

Computer-based education was performed in a lecture room equipped with personal computers per student, which have access to Internet. The students were guided to access electronic bulletin board and to read and follow the instructions that tell them what to do and how to download the training program materials. The training contents were developed using Microsoft PowerPoint. Students' learning activities are basically self-directed and the instructor did not interfere into the learning process except when any malfunction is observed. The contents were designed in a modularized format.

2.1.2 Technique-oriented training program and factor-oriented training program

Each training program took 4 weeks and was consisted of 8 sessions. Two 30-minutes sessions were arranged per week. In technique-oriented training program, students were trained to apply

〈Table 1〉 Specification of Creativity Training Programs

Creative Technique-Oriented Training Program		# of Material Pages	
Name of Technique	Content	Computer-based	Paper-Pencil
Unusual Uses	Finding the unusual uses	3	1
Forced Relationships	Forced relationships with unrelated things	6	1
SCAMPER	Ten kinds of idea making	6	1
Get Crazy	Get crazy in the problem solving	3	1
Faults Listing	Looking for the faults and finding resolutions	3	1
Wishes Listing	Listing the wishes and finding realization	3	1
Attribute Listing	Listing and classifying attributes of thing then improve it	5	1
PMI	Finding plus, minus, and interesting things of idea	3	1

Creative Factor-Oriented Training Program			# of Material Pages	
Creativity Factor	Creative Thinking sub-factors	Creative Personality sub-factors	Computer-based	Paper-Pencil
Feel it	Fluency, Flexibility	Curiosity, Openness	3	1
Making List	Flexibility, Fluency	Openness, Independence, Curiosity	3	1
Unusual naming	Originality, Elaboration	Humor, Independence	3	1
Happiness is·	Elaboration	Self Confidence, Independence	5	1
Imagination is·	Originality, Elaboration	Imagination, Openness	3	1
Finding Common	Flexibility	Perseverance/ Persistence	3	1
World cup in 2001	Elaboration, Fluency	Perseverance/ Persistence, Curiosity	4	1
School in Future	Originality	Self Confidence, Imagination	2	1

different creativity improvement techniques. In factor-oriented training program, students learned case-type contents developed by authors, which include creativity sub factors such as creative personality and creative thinking. Basic configurations of the two types of programs are presented <Table 1>.

2.2 Experimental Task and Measure

Creative Figural Tests used for the pretest and posttest were developed by authors by adjusting existing instruments used to measure the level of general creativity. Here, the participants were asked to draw as many objects or pictures as possible in ten minutes based on the stimulus. The scores for creative fluency, flexibility, and originality were counted and computed by two scores based on predefined categorization rule. The inter-rater reliability was 0.98. The operational definitions of the creative fluency, flexibility, and originality are as follows.

Fluency : the number of ideas or images produced by the subjects

Flexibility : the number of categories where the outcomes belong

Originality : infrequency and unusualness of the response (Outcomes appeared commonly in over 10% of the subjects were scored 0 ; Outcomes appeared commonly in 5 to 10% of the subjects were scored 1 ; Outcomes appeared commonly in 1 to 5% of the subjects were scored 2 ; Outcomes appeared commonly in less than 1% of the subjects were scored 3).

Creative Product Test measured the level of creativity applied to a certain domain-specific problem. In this research, producing ideas for the creation of a new business was assigned as the experimental task. Two coders evaluated the level of creativity of the outcomes based on a set of pre-defined rules. The inter-rater reliability was 0.74. The scores for this domain specific creativity task were obtained for all students.

2.3 Experimental Subjects

Four groups of vocational high school students totaling 151 were used as experimental subjects. Experimental administration of each group was implemented as independent class. The students possessed basic skills to use Internet and MS PowerPoint as well as basic understandings of business environment, which they learned from previous courses. The students were all second year students in a vocational school, which focuses on training job-related education in the area of information and communication industry.

2.4 Pre-test and Calibration

Both a Creative Figural Test (CFT) and a Creative Product Test (CPT) were administered as pretests before the 8 training sessions were delivered. Comparison of the pretest results was performed to check the existence of differences in initial conditions. We also analyzed the effects of the level of academic achievements (high, medium low). MANOVA results of the pretest were presented <Table 2>. There was no significant difference among the Creative Figural Test score of the twelve groups (four experimental groups, and each divided by educational achievement level). Since the scores of the Creative Product Test showed some differences among the four

<Table 2> MANOVA and ANOVA results of the pretest scores across the level of academic achievement, type of education environment (computer-based or not), and the type of training program

Independent Variables	Pillai's Trace (Sig.)	Dependent Variables	F(ANOVA)
Ach	.071 (.079)	CFT	1.363
		CPT	2.512
Edu	.108 (.001)	CFT	1.588
		CPT	**9.432****
Pro	.001 (.938)	CFT	.130
		CPT	.008
Ach × Edu	.037 (.367)	CFT	1.230
		CPT	.519
Ach × Pro	.008 (.921)	CFT	.217
		CPT	.259
Edu × Pro	.059 (.030)	CFT	.849
		CPT	**4.831***
Ach × Edu × Pro	.007 (.930)	CFT	.336
		CPT	.023

Note : Ach = Level of Academic Achievements ;
Edu = type of educational environment (Computer-based vs. paper-pencil) ;
Pro = type of creativity training program (Technique oriented vs. Factor oriented) ;
CFT = Creative Figure Test scores ;
CPT = Creative Product Test scores

Note) * : $p < .05$, ** : $p < .005$

groups, we adjusted the data analysis of the scores of Creative Product Test by using differences between posttest scores and pretest scores as corrected measure in the final result analyses.

3. Results

Post-tests were administered one week after the completion of the training. Means and Standard deviations of the pretest and posttest scores of the four treatment groups are presented in <Table 3>.

Hypothesis 1

Results of paired t-test (pretest and posttest) are summarized in <Table 4>. The results show that the treatment effects in terms of CFT were significant for three out of four groups. For the one group with paper-pencil environment and technique-oriented training, the average score of the level of creativity had increased, but was not significant at the level of $p < 0.05$ but it was under the range of $p < 0.10$. However, results of creative product test did not show any significant improvement. Therefore, hypothesis 1 is partially accepted.

Hypothesis 2

A MANOVA was performed on the scores of posttests to analyze the interaction effects of

〈Table 3〉 The Means and Standard Deviations of creativity test scores of the four experimental groups

Education Environment	Program Type	Mean (SD) of CFT		Mean (SD) of CPT		N	
		Pretest	Posttest	Pre	Post	Pre	Post
Computer based education	Technique -Oriented	33.53 (10.28)	55.16 (17.72)	11.91 (3.63)	12.64 (4.51)	32	33
	Factor -Oriented	31.94 (13.34)	46.15 (16.02)	14.18 (3.16)	14.09 (3.72)	34	34
Paper-pencil setting of education	Technique -Oriented	32.76 (15.80)	39.55 (23.66)	11.06 (5.19)	11.42 (4.65)	30	30
	Factor -Oriented	38.50 (19.80)	52.63 (22.58)	9.16 (7.61)	11.16 (5.75)	32	32
Total		34.45 (15.44)	48.28 (20.71)	12.46 (4.68)	12.46 (4.55)	128	129

〈Table 4〉 paired t-test results to compare the effects of creativity training

		Technique-oriented		Factor-oriented	
		t	Sig.	t	Sig.
Computer-based	CFT	-8.035	**.000**	-4.769	**.000**
	CPT	-.723	.472	.113	.910
Paper-pencil	CFT	-1.843	**.076**	-3.107	**.004**
	CPT	-.340	.736	-1.626	.114

Note) CFT = Creative Figural Test ; CPT = Creative Product Test

〈Table 5〉 MANOVA & ANOVA results on the scores of posttest

Independent Valuable	Pillais Trace (Sig)	Dependent Valuable	F (ANOVA)
Ach	.006 (.954)	CFT	.136
		CPT	. 212
Edu	.010 (.543)	CFT	1.034
		CPT	. 023
Pro	.005 (.749)	CFT	.469
		CPT	.018
Ach × Edu	.021 (.657)	CFT	.978
		CPT	.561
Ach × Pro	**.084 (.040)**	CFT	2.090
		CPT	**2.434**$^{+}$
Edu × Pro	**.092 (.004)**	CFT	**9.914****
		CPT	.220
Ach × Edu × Pro	.020 (.670)	CFT	.599
		CPT	.311

Note) Ach = Level of Academic Achievements ;
Edu = type of educational environment (Computer-based vs. paper-pencil) ;
Pro = type of creativity training program (Technique oriented vs. Factor oriented) ;
CFT = Creative Figure Test scores ;
CPT = Creative Product Test scores

achievement level, educational environment, and the type of training program. The results of MANOVA and follow-up univariate ANOVA results are presented in <Table 5>. Results of MANOVA indicate that two significant interaction effects exist. One of the meaningful effects was that of the interaction between achievement level and the type of training program ($p < .05$) and the other was the effects of the interaction between educational environment and the type of training program ($p < .005$). According to ANOVA results, significant interaction effects between achievement level and the type of training program in terms of the scores of creative product test ($p < .10$). Another significant interaction effects by score was the effect of the interaction between educational environment and the type of training program type exist on the scores of creative figural test ($p < .005$). Therefore hypothesis 2 is partially accepted.

Hypothesis 3

Correlations among achievement level, Creative Figural pretest scores, Creative Product pretest scores, Creative Figural posttest scores, and Creative Product posttest scores are shown in <Table 6>. Correlation between achievement scores and Creative Product pretest scores, correlation between Creative Figural pretest scores and Creative Figural posttest scores, correlation between Creative Product pretest scores and Creative Product posttest scores, and correlation between Creative Figural posttest scores and Creative Product posttest scores are the relations with statistical significance. Therefore hypothesis 3 is partially accepted.

4. Discussion

Some conclusive discussions can be drawn from the experimental results.

First, contributing effects of creativity training was found regardless of the dimensions of treatment. Specifically, the Creative Figural Test scores have improved in all the four experimental

〈Table 6〉 Correlations Among Achievement level, Pretest Scores, and Posttest Scores

	Achievement	Creative Figural Pretest	Creative Product Pretest	Creative Figural Posttest	Creative Product Posttest
Achievement	1.000	-.012	.186*	.052	.001
Creative Figural Pretest		1.000	.170	.393**	.131
Creative Product Pretest			1.000	.158	.290**
Creative Figural Posttest				1.000	.236**
Creative Product Posttest					1.000

Note) * $P < .05$ ** $P < .01$

groups. The creativity training programs might have stimulated student's conscious interests in creative work in both computer-based and paper-pencil environment. The lack of significant improvement in Creative Product Test scores might imply the difficulties in domain-specific transfer of the training effects, especially in a limited time.

Second, the technique-oriented creativity training was more effective than the factor-oriented under the context of computer-based education, and the factor-oriented training was more effective in the paper-pencil setting. These results suggest that different pedagogical approaches should be employed for computer-based training as compared to the paper-pencil education.

Third, there was no difference in the creative test (figural test and product test) scores across the level of academic achievement, signifying the lack of relationship between academic achievement levels and the level of creative achievement. In the pretest, we could observe correlations between the level of academic achievement and Creative Product Pretest score, most of which disappeared in posttests. This result implies that the provision of creativity training can help students to overcome some aspects of cognitive performance defects. It is needed to further examine the role of domain specific knowledge for creative performance of tasks in future research.

We could conclude that the employment of computer-based learning environment can improve at least some aspects of creativity performance. The amount of the changes in the effects of the use of technological medium depends on the method of training. This result implies that the methods of training should be adjusted to optimize the effectiveness of learning in electronic environment. For example, different training method involves different level of learners' active participation and commitment. Methods that provide higher learner involvement and improved incentive for participation have higher possibility to increase educational performance. Moreover, electronic creative training has the advantage to overcome spatial and temporal constraints. Despite these advantages, not sufficient creativity training programs and techniques have yet been offered, resulting in high demand for the development of diverse technology-based creativity training programs.

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