

# Differences in Creative Personality and Attitude, Creative Problem Solving, and Convergence Thinking of College Students According to Self-Regulation and Cognitive Flexibility Training VR Program Participation

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## Abstract

This study used a cognitive flexibility training VR program that can view and solve problems from various perspectives, self-regulation, and self-regulation with the super cognitive ability required for creativity to improve college students' creative personality and attitude, creative problem solving, and convergence thinking ability. In addition, differences in creative personality and attitude, creative problem solving, and convergence thinking ability were analyzed before and after participation in the program. In this study, 55 students were recruited voluntarily among four-year E University students in Gyeonggi-do. The experimental tool is VR content developed by FNI Co., Ltd. The main contents are mainly composed of improving self-control ability, strengthening positivity, and enhancing interpersonal relationships. The IBM SPSS Statistics 25 program was used to analyze the collected data to test the research question. First, frequency analysis and descriptive statistical analysis were performed to examine the mean and standard deviation of the sociodemographic factors and measurement variables of the subjects. Moreover, to determine how consistently the measuring instrument was used, the reliability was validated by calculating the Cronbach's coefficient value. Furthermore, factor analysis was utilized to minimize the number of items in the developed measurement tool by removing variables unrelated to the component to be studied. Factor analysis has the purpose of reducing variables, removing unnecessary variables, identifying variable characteristics, evaluating the validity of measurement items, and creating variables using factor scores. In addition, to confirm the statistical significance of the average values of creative personality and attitude, creative problem solving, and convergence thinking before and after participating in the VR program, a matched-sample t-test was performed. As a result of the study, it was found that participation in the self-regulation and cognitive flexibility VR program had a positive effect after participation compared to before participation in creative personality and attitude, creative problem solving, and convergence thinking.

**Keywords:** self-regulation, cognitive flexibility, VR program, creative personality and attitude, creative problem solving, convergence thinking

## 1. Introduction

It was discovered that college students had creativity-related education as a required skill in the fourth industrial revolution period and the education they want to get at university to prepare for it. In addition, it was found that creativity development, major-related knowledge, problem-solving ability, and critical and analytical thinking were recognized as important learning outcomes that must be obtained through university classes (Kim, et al., 2017; Kim 2020). Creativity development, in particular, is being highlighted as the ability to adjust to rapid social changes and lead the future society. Therefore, to creatively perform work in the relevant field and produce outstanding outputs, the creative talents we need to seek must have balanced creative capabilities in knowledge, attitude, and social domains. In addition, they should be able to demonstrate creativity and produce new and valuable things in a social context.

In a society where technology is advanced and knowledge is abundant, and the cycle of knowledge extinction is shortened, it is critical to produce new knowledge rather than rely on an individual's knowledge and to creatively use current knowledge. Creativity is used to encompass the ability to create new and novel things as 'the ability to create new relationships outside of the traditional way of thinking or to generate unusual ideas' (Korean Educational Psychology Association, 2000). Such creativity has recently been viewed as desirable to evaluate creative individuals through an integrative approach that integrates cognitive and affective approaches (Martindale, 1989; Song & Kim, 1999; Seong, Park & Kim, 2003). Environments that express creativity in the cognitive and affective aspects constituting creativity appear as they interact with each other (Woodman, Schoenfeldt, 1989), and the convergence of these elements is not due to simple summation, but overlapping relationships or interactions between elements. It should be understood that it is a complex concept that requires consideration of action and effect (Han et al., 2005). In the past, creativity was thought to be possessed at birth, but now it is believed that creativity can be enhanced through education.

As a result of the study confirming the relationship between creativity and self-regulated learning, it was found that the two variables had a positive correlation in the study between self-regulated learning and creative thinking for college students (Chung, 2007; Jung et al., 2009). In addition, there is a previous study that showed that students who received learning activities to which self-regulated learning strategies were applied showed significantly higher creative tendencies and creative attitudes than those who did not (Jun & Cha, 2009). In this way, creativity is also defined as a 'self-regulating metacognitive process' (Chung, 2007; Pesut, 1990). This is because creativity includes recognition of one's attention and recognition processes and the process of strengthening, evaluating, and checking oneself (Chung, 2007). In addition, creativity requires the hypercognitive ability (Lee et al., 2009), and this hypercognitive ability is a key factor in self-regulated learning. In addition, in the learner-centered learning process, students address issues through creative thinking, implying that creative thinking is closely related to self-regulated learning.

Therefore, this study aims to investigate changes in the creative personality and attitude, creative problem solving, and convergence thinking of college students through VR-based self-regulation and cognitive flexibility training programs. The research questions set to achieve these research objectives are as follows.

First, what is the level of creative personality and attitude, creative problem solving, and convergence thinking before and after participating in the VR program?

Second, what are the differences in creative personality and attitude, creative problem solving, and convergence thinking before and after participating in the VR program?

## 2. Literature Review

In a previous study on the relationship between creativity and cognitive flexibility (Hong, 2005), the group with high flexibility showed higher scores on the creativity test than the group with low flexibility. The group with high flexibility, in particular, generated more creative and diverse ideas and was able to develop ideas in detail and concretely, indicating that flexibility has a strong association with creative performance. Snyder (1974) stated that those who can regulate themselves are more adaptive because they show flexibility to respond quickly and effectively to the needs of others and various social roles in social situations. Cognitive flexibility is defined as the ability to come up with creative new ideas, to look at and solve problems from multiple perspectives, and to be interested in and not avoid complex and new situations and problems. In other words, cognitive flexibility is the knowledge that numerous options and alternatives are accessible in any given scenario, the spontaneity to adapt and adapt to the situation, and self-efficacy in flexibility (Hong, 2005, Martin & Rubin, 1995).

As such, research related to ways to enhance creativity is continuously being conducted. Recently, in the 'Edu-Tech' era, creativity education that combines VR (virtual reality) and art has appeared. To prepare for the rapidly changing digital era, a new tool called VR is being grafted into creative and artistic education instead of teaching aids. Virtual reality and augmented reality bring many changes from the existing dictionary definitions according to the recent changes in many devices. In particular, the definitions of virtual reality, augmented reality, and mixed reality bring various changes depending on the compatibility of hardware and content. Changes in the characteristics of immersive VR devices, location-aware-based AR, and spatial and object recognition-type MR (mixed reality) are foretelling rapid changes in the environment of virtual reality. With the release of various content by devices of Oculus and HTC Vive, virtual reality is forming a market through hardware and expanding the market through software content. Moreover, in the virtual reality-based environment, these two devices play a large role in market formation. VR technology is a new technology field that can provide various benefits by substituting or restructuring

various environments, contents, and workflows that occur in industrial sites, centering on IT. In particular, for education to be tailored to the interests and characteristics of university students called digital natives, VR can be an essential learning content like internet lectures and digital textbooks. In addition, in the virtual reality environment, learners can participate as actors and experience the joy of creating a dynamically changing world (Park & Lee, 2004). In addition to this, virtual reality delivers a powerful sensation to the user, and the features of presence and immersion have a beneficial effect that boosts the user's satisfaction (Nichols et al., 2000; Whitelock et al., 2000). Through interaction with the virtual environment, interesting and new perspectives are obtained, which increases enjoyment and ultimately increases motivation for information processing (Sicilia et al., 2005; Novak & Hoffman, 1997).

### 3. Research Method

#### 3.1 Research Design

This study was designed as follows.

First, data collection was empirically conducted through experiments and surveys. The sampling method used in this study was conducted in a way suitable for this study through the recruitment of volunteers. In addition, the number of respondents was sufficient to achieve the goal of this study and to answer the survey.

Second, the experimental study design that examined the impact of participation in the VR program in this study was a single group pre-post design.

Third, the consent form of the research participants who complied with research ethics standards such as personal information protection and prior consent was collected from the subjects who participated in the study before participating in the study.

#### 3.2 Study Subject

This study was conducted from October 23rd to November 25th, 2021 for college students enrolled in a four-year university in Gyeonggi-do. In addition, applicants were voluntarily recruited as students taking liberal arts courses to participate in the VR program for self-regulation and cognitive flexibility training. Moreover, to comply with research ethics standards such as protection of personal information and prior consent in online surveys conducted by individuals, consent forms from research participants were collected and submitted in electronic file format during online surveys.

**Table 1.** General Characteristic (N=55)

Observational variable		Frequency	%
Sex	Male	15	27.3
	Female	40	72.7
Grade	1	6	10.9
	2	1	1.8
	3	48	87.3
Department	Department of Emergency Rescue	21	38.2
	Department of Radiology	19	34.5
	Department of Physical Therapy	15	27.3

#### 3.3 Research Procedure

This study was designed to investigate the effects of participation in a VR program for self-regulation and cognitive flexibility training for college students on creative personality and attitude, creative problem solving, and convergence thinking. The independent variable of this study is a VR program developed to improve self-regulation and cognitive flexibility, and the dependent variables are creative personality and attitude, creative problem solving, and convergence thinking.

First, to examine the effects of participation in a VR program for self-regulation and cognitive flexibility training for college students on creative personality and attitude, creative problem solving, and convergence thinking, we developed a questionnaire on creative personality and attitude, creative problem solving, and convergence thinking. In addition, the feasibility was analyzed. Before participating in VR program activities, pre-tests were conducted on creative personality and attitude, creative problem solving, and convergence thinking. From October 23rd through

November 25th, 2021, the program participation period was repeated 15 times. After participating in the VR program, post-tests were conducted on creative personality and attitude, creative problem solving, and convergence thinking in the same way.

### 3.4 Research Tool

The creative personality and attitude, creative problem solving, and convergence thinking questionnaires used in this study were self-developed through literature review, so the reliability and validity of the questionnaires were analyzed. For the data of literature review for questionnaire development, based on the measurement tool developed by Zhou and George (2001), the questionnaire used by Choi Woong-cheol (2013), Jang An-ri (2016) and Lee Deajung (2020) was modified and used. The creativity test has 15 items in total, with the sub-factors creative personality and attitude (5 items), creative problem solving (5 items), and convergent thinking (5 things) on a 5-point Likert scale. Each item has a point value ranging from 'not at all (1 point)' to 'strongly agree (5 points)', with higher scores indicating more positive creativity. Reliability for each sub-factor was .757 for creative personality and attitude, .728 for creative problem solving, .610 for convergence thinking, and Cronbach's  $\alpha$ =.731 for overall reliability. The composition and reliability analysis results of the questionnaire are as follows.

**Table 2.** Result of Analysis of questionnaire Composition and Reliability of Questionnaire Questions

Category	number of questions	Cronbach' $\alpha$
creative personality and attitude	5	.757
creative problem solving	5	.728
convergence thinking	5	.710

The results of factor analysis to confirm the validity of the questionnaire is as follows. The results are generally presented, and there are factor load, commonality, eigenvalue, descriptive variance, and cumulative variance appearing in the factor matrix after rotation.

**Table 3.** Validity Analysis Result of the Question

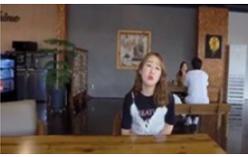
	Factor				
	1	2	3	4	5
3-2-4-1	0.752	0.029	0.334	0.272	-0.134
3-2-5-1	0.632	0.468	0.062	0.299	0.074
3-1-4-1	0.597	0.053	0.068	-0.115	0.438
3-1-3-1	0.568	0.395	0.176	-0.002	0.187
3-2-3-1	0.524	-0.114	0.134	0.347	0.297
3-3-3-1	0.430	0.690	0.001	-0.124	-0.115
3-2-1-1	0.001	0.670	0.395	0.321	-0.011
3-2-2-1	0.043	0.657	0.143	0.294	0.138
3-3-4-1	0.028	0.621	0.141	0.072	0.507
3-1-2-1	0.141	0.205	0.907	0.035	0.084
3-1-1-1	0.185	0.081	0.883	0.158	0.098
3-1-5-1	0.400	0.258	0.481	-0.131	0.286
3-3-2-1	0.234	0.117	0.144	0.871	-0.042
3-3-1-1	0.006	0.206	-0.011	0.854	0.094
3-3-5-1	0.155	0.076	0.121	0.077	0.832
eigenvalue	5.125	1.683	1.305	1.287	1.023
descriptive variance	34.17	11.22	8.70	8.60	6.82
cumulative variance	34.17	45.39	54.08	62.66	69.50
number of questions	5	4	3	2	1

Factor extraction method: principal component analysis  
 Rotation method: Varimax  
 Reason for factor extraction: Eigenvalue (1.0)

This table shows the structure of factors calculated based on the eigenvalue of 1.0. The overall explanatory variance of this five-factor model is fairly high at 69.50 percent, with factor 1 accounting for 34.17 percent, factor 2 accounting for 11.22 percent, factor 3 accounting for 8.70 percent, factor 4 accounting for 8.60 percent, and factor 5 accounting for 6.82 percent. Therefore, it was confirmed that the creative personality and attitude, creative problem solving, and convergence thinking measurement tools developed for this study accurately reflect the properties of the concept to be studied.

3.5 Experimental Tool

**Table 4.** Details of VR-based Self-Regulation and Cognitive Flexibility Training Program

Category	Contents	Related screens
self-regulation program	Anger control training It is to present an anger situation and to train how to control impulsive emotions.	
	Calm breathing training It is an exercise in deep breathing following the sounds heard in the virtual forest to clear the mind.	
	Endurance training to stay focused It is an endurance exercise to stay focused in boring and repetitive situations.	
	Reinforcement training for self-strength and positivity It is a training to express one's strengths listed in a presentation in front of a small group composed of virtual reality and to reinforce one's strengths and positivity.	
	Gratitude training It is an exercise in recalling daily life and things to be grateful for with family and friends, expressing in virtual reality, and re-experiencing positive experiences in real life.	
Cognitive Flexibility Programs	Training to establish a positive future view and self-image It is training to compare one's past and future, present it in front of a small group, and establish one's positive future outlook and self-image.	
	Training to understand the point of view of others This is training that promotes the improvement of the ability to understand the mind by checking the situation related to oneself from the second or third person's point of view.	
	Training to express empathy for others It is training to identify situations that provoke emotional reactions to others, to count empathic emotions felt in these situations, and to express empathy to others in virtual reality.	
	Bullying overcoming training It is training to properly solve problems without being emotionally overwhelmed in a bullying situation.	

The experimental tool used in this study is a VR-based self-regulation and cognitive flexibility training program developed by FNI, which aims to strengthen self-control ability and positivity and enhance interpersonal relationships through motivational reinforcement training for multifaceted problem-solving. The main contents are mainly composed of improving self-control ability, strengthening positivity, and enhancing interpersonal relationships. The contents of the self-regulation and cognitive flexibility training VR program are as above in table 4.

### 3.6 Data Analysis

The IBM SPSS Statistics 25 program was used to analyze the collected data to test this research question. First, frequency analysis and descriptive statistical analysis were performed to examine the mean and standard deviation of the sociodemographic factors and measurement variables of the subjects. Moreover, to determine how consistently the measurement tool was used, the reliability was validated by calculating the Cronbach's coefficient value. In addition, factor analysis was used to reduce the number of items by deleting variables not related to the factor to be studied in the developed measurement tool. In addition, to confirm the statistical significance of the average values of creative personality and attitude, creative problem solving, and convergence thinking before and after participating in the VR program, a paired sample t-test was performed.

## 4. Research Results

### 4.1 Descriptive Statistical Analysis of Creative Personality and Attitude, Creative Problem Solving, and Convergence Thinking before and after Participating in the VR Program

Table 5 shows the results from an analysis of descriptive statistics on creative personality and attitude, creative problem solving, and convergent thinking before and after college students participated in the VR program.

**Table 5.** Descriptive Statistical Analysis (N=55)

		Mean	Std. Deviation
Pair 1	Pre-creative personality and attitude	3.3273	.43608
	Post-creative thinking and attitude	3.9200	.43478
Pair 2	Pre- creative problem solving	3.2727	.43267
	Post- creative problem solving	3.8145	.37487
Pair 3	Pre-convergence thinking	3.3527	.37705
	Post-convergence thinking	3.8873	.43164

In Table 5, scores after participation in the VR program were higher than before participation in the VR program in all of creative personality and attitude, creative problem solving, and convergence thinking. The average value before participation in the program was 3.317. The average value after participating in the program was 3.873.

### 4.2 Analysis of Average Differences in Creative Personality and Attitude, Creative Problem Solving, and Convergence Thinking before and after Participating in the VR Program

Table 6 shows that the paired-sample t-test was performed to check whether the difference between the pre-score and post-score of college students' creative personality and attitude, creative problem solving, and convergence thinking scores were statistically significant for self-regulation and cognitive flexibility VR program participation.

As a result of the paired-sample t-test, the difference between the mean values of pre-and post-creative thinking and attitude was t-value  $-15.405$ , and the probability of significance was  $.000$ , showing a statistically significant difference ( $p < .001$ ). That is, it was judged that there was a positive effect on creative thinking and attitude after participation in the self-regulation and cognitive flexibility VR program. In addition, the difference between the mean values of pre-and post-creative problem solving was t-value  $-.54182$ , and the probability of significance was  $.000$ , showing a statistically significant difference ( $p < .001$ ). That is, it was discovered that participation in the self-regulation and cognitive flexibility VR program had a good influence on creative problem-solving. Lastly, the difference between the mean values of pre-and post-convergence thinking was t-value  $-.53455$ , and the probability of significance was  $.000$ , showing a statistically significant difference ( $p < .001$ ). Hence, it was determined that participation in the self-regulation and cognitive flexibility VR program had a good influence on convergent thinking.

**Table 6.** Paired Sample t-Test Result (N=55)

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-creative personality and attitude – Post-creative thinking and attitude	-.59273	.28536	.03848	-.66987	-.51558	-15.405***	54	.000
Pre-creative problem-solving – Post-creative problem solving	-.54182	.23309	.03143	-.60483	-.47881	-17.239***	54	.000
Pre-convergence thinking – Post-convergence thinking	-.53455	.23111	.03116	-.59702	-.47207	-17.153***	54	.000

\*\*\* $p < .001$

## 5. Discussion

About this study, previous studies claim that creativity is effectively explained by arguing that it is dependent on emotions such as self-regulation and cognitive flexibility (Damasio, 1994; Radford, 2004, Ki, 2017). In particular, in the self-regulation and cognitive flexibility VR program, which is an experimental tool used in this study, Virtual Reality (VR) technology that provides immersion and new experiences has been steadily developed and applied to the educational field, but its expectations and concerns suggest positive implications.

The following implications can be drawn from these research results. Various educational programs have been developed in the past as educational methods to promote creativity, and numerous experimental studies have been conducted. Education can expect educational effects only when the characteristics of learners are understood and education media and methods that reflect their needs are introduced. It is the 4th industrial revolution era, and learners are the digital native generation, so the use of cutting-edge digital educational media is no longer a simple experience-oriented media, but can be used in various ways in the educational field. In addition, the fact that college students are strongly aware of the importance and necessity of creative education is the result of the efforts of universities to educate students on creativity in their way over the past 20 years. However, compared to students' high expectations for creativity education, students' opportunities or experiences for creativity are not satisfactory.

VR, which depicts a three-dimensional virtual environment produced by a computer or smart device, is portrayed in such a way that learners may experience it in three dimensions, much like the real world. In addition, depending on the input/output device, the sense of touch can be sensed by sight and hearing. As such, in the results of this study, VR-based educational media and programs can contribute to enhancing the effectiveness of education, and in particular, experiencing the self-regulation and cognitive flexibility of learners necessary to promote creativity through VR has a positive effect.

The conclusion of the first research question is as follows: The average value before participation in the program was 3.317. The average value after participating in the program was 3.873.

The conclusion of the second research question is as follows: It was confirmed that the difference between the pre-score and post-score in the creative personality and attitude, creative problem-solving ability, and convergence thinking ability score of college students was improved through participation in a VR-based program that enhances self-regulation and cognitive flexibility.

As such, the significance of this study is as follows.

First, in the fourth industrial revolution age, the ability to effectively choose diverse knowledge and technologies and apply them to organize and produce new values is necessary. In particular, creativity is necessary for college students to have competitiveness in the era of the 4th industrial revolution. This study has the greatest significance in that it confirmed the creativity level of college students according to the flow of these times.

Second, although various variables have been studied for creativity, studies on self-regulation and cognitive flexibility variables have been lacking. This study provided specific information necessary to promote creativity.

Third, the study on the educational effectiveness of the introduction of VR programs suitable for the digital native generation among various programs to promote creativity is meaningful in that it confirms the positive effects of VR devices in the introduction of creative educational media in the future.

## 6. Conclusion

This study intends to examine changes in creative personality and attitude, creative problem solving, and convergent thinking among university students who participated in a self-regulation and cognitive flexibility VR program. With this, a survey was conducted on college students enrolled in 4-year E-University in Gyeonggi-do, asking about their creative personality and attitude, creative problem solving, and convergence thinking before participating in the self-regulation and cognitive flexibility VR program. After participating in the self-regulation and cognitive flexibility VR program for 3 weeks, a survey was conducted. The study found that participation in the self-regulation and cognitive flexibility VR program resulted in positive changes in creative personality and attitude, creative problem solving, and convergent thinking after participation compared to before participation.

Despite these implications, this study has several limitations.

First, there is a limitation in that the research results cannot be generalized in that the survey subjects were students from a single university.

Second, there is a limit to the interpretation of the research results in that they were not evenly selected by major because they were research results for some majors without considering all the characteristics of the study subjects by major.

Third, this study may be limited in that data were collected through a self-report questionnaire. Self-reporting surveys have limitations as they may not be able to accurately express themselves because they depend on the reports of those who took part in the survey. Therefore, in follow-up studies, research should be conducted through methods to obtain practical data, such as the routine reconstruction method and the empirical sampling method.

To solve these limitations, it is necessary to expand the scope of research subjects for various major fields and university students in follow-up studies.

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