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Development and Validation of the Korean Simple Integrated Creativity Test (K-ICT-S)

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The purpose of this study was to develop and validate an integrated creativity test that can easily measure college students' creativity (creative ability, creative personality). The Simple Integrated Creativity Test (ICT-S), designed to facilitate group online testing with greater ease of scoring on the basis of previous studies, was reconstructed the K-ICT (Lee, 2014) into an object-type instrument, and validated as measuring creative ability and creative personality in an integrated method. Creative ability was measured in terms of fluency, elaboration, imagination, sensitive thinking, and originality through five activities in the language and drawing domains. Creative personality was scored on a 5-point Likert scale along the dimensions of curiosity, sensitivity, task commitment, humor, and independence. The participants were 775 college students, and the collected data were analyzed through descriptive statistics, correlation, reliability verification, exploratory factor analysis, and confirmatory factor analysis. Overall reliability was shown by Cronbach's α.= 877, and the internal consistency of the items was good, as were the factor coefficient, fit, and correlation coefficient according to tests of validity. Thus, the K-ICT-S was confirmed as a tool with proved reliability and validity for measurements of creativity integrating college students' creative ability and creative personality.

Key words: *creative ability; creative personality; creativity; simple integrated creativity test; university student*

Introduction

Rapid developments in science and technology have influenced not only economic circumstances but also political, cultural, educational, and living conditions worldwide, entailing swift environmental changes. It is, however, difficult to both estimate the pace of technological development and predict the resulting dynamic social changes. Moreover, the world has become hyper-connected with the acceleration of globalization brought on by the Internet and IT revolution, resulting in close online and offline interactions. Following the unforeseen outbreak of the COVID-19 pandemic, however, the world has entered a state of emergency. Such a circumstance calls for creative leaders who are also creative problem solvers to address this crisis.

While it is important to have creative talents in every field to overcome the current crisis, talented individuals having a creative personality and the core competencies a leader needs in the highly unpredictable circumstances of future society are also necessary. Shullman (2020) asserted that to handle a crisis such as ours, leaders need a creative personality—with such traits as curiosity, flexibility, and risk-tolerance—as well as the ability to adapt to the influx of complicated information necessary for effectively addressing the problems that might arise in future society. With regard to the creative-convergent talent likely to be needed in future society, Lee (2017) stated that there must be individuals capable of the following: possessing insight into rapidly changing social situations; thinking confluently while drawing on knowledge encompassing a variety of fields; combining flexible and original creative thinking with an open, sensitive, and creative personality; and managing new and diverse problems. Lee coined such capabilities as *future creative confluence competency* (F3C), defined as "an integrated psychological resource comprising creative thinking ability, confluence ability, and future talent characteristics, which will facilitate an active response to various situations in a rapidly changing future society" (2020).

In an intellectual-property-based society in the hyper-cognition and hyper-connection era, there is increased demand for cultivating creative talents and leaders capable of convergent thinking, and thus the systematic development of creativity through school education has become even more necessary. Meanwhile, creativity is considered a characteristic that anyone could and should have in future society, rather than an ability bestowed upon special individuals, which has made it an important keyword in education. This is another factor that affects the demand for creativity education.

South Korea's education policy on creativity can be observed in the 2009 Revised Curriculum, which focuses on creativity and character building to "foster talented creative individuals who care for others and practice sharing." To fulfill the aforementioned purpose, diverse programs that aim to build creativity through school education have been developed and applied. Emphasis has been placed on creativity as a key competency that global talents in the 21st

century need for leadership in future society. However, there are evident gaps between the country's creativity education and the actual educational situation in colleges. In other words, while universities have made individual efforts to foster creative individuals by promoting creativity-strengthening education and the development of capstone design classes through their educational development centers, this is a relatively recent trend. There appears to be a consensus that now is the time to impart education that can cultivate globally competent creative individuals. To impart creativity education through school education, however, it is essential to identify differences in students' creativity—only then can an appropriate educational program be developed. Therefore, it is necessary to develop and apply an instrument to measure creativity taking into account the developmental levels from infancy to adulthood, and in particular reflecting the learners' traits by school year. Not only is a validly developed creativity test needed to accurately measure students' creativity according to their developmental level, but deliberate education is necessary to enhance students' creativity and creative problem-solving skills by considering their abilities and personalities (Lee & Lew, 2012).

According to earlier research on creativity development (Lee, 2002a, 2002b, 2002c, 2003a, 2003b, 2006), developmental trends are neither continuous nor consistent from childhood to adolescence. Thus, it is necessary to conduct an in-depth study of the discontinuities in such trends as well as research on creativity education that can foster creative Korean talents in light of the country's situation. Moreover, a creativity study that relates infancy to college years is also needed. Such a study, however, cannot be carried out properly because a relatable creativity test that can consistently measure creativity from infancy to adulthood is yet to be developed. Furthermore, an easily conducted test that considers testing circumstances is rare in the area of creativity. In particular, the majority of standardized creativity tests have been developed for infants and children (Lee, 2011). Therefore, there is an exceptional need for a creativity test with verified validity developed in South Korea to reflect Korea's cultural and social circumstances and school curriculum and targeting primary and secondary school students as well as college students. Lee (2002, 2012, 2014) developed a valid standardized creativity test (Korean Integrated Creativity Test [K-ICT]) that can comprehensively measure young children and school students' creative thinking ability and creative personality; it has even been applied in schools. However, there has been no standardized test that comprehensively measures college students' creative thinking ability and creative personality. Scholars are still debating the definition of creativity and how it should be measured. While there have been numerous studies on the measurement of creativity, most lack a universal standard. Moreover, some Korean scholars measure it from a single perspective of either cognitive or personality factors, such as creative thinking ability or creative tendency. In other words, most creativity measuring tools that have been developed and used so far have approached creativity as either a cognitive skill or a personality trait and placed age restrictions on test takers, such as infancy, childhood, or adulthood (Lee & Lew, 2012).
This study, therefore, used Lee's (2014) K-ICT to develop and validate an integrated creativity

test for college students that can easily and comprehensively measure their creative thinking ability and creative personality through multiple-choice questions either online or offline. The bases for developing a creativity test in this study are as follows. Lee (2003a, 2003b), implementing the Volcano model (a creativity concept model), proposed that creativity is an amalgamation of creative thinking ability and creative personality; his later works (2004, 2005) proposed Triple Three Model, measuring integrated creativity. On this basis, the current study accepted the concept of integrated creativity when measuring college students' creativity and selected sub-factors of creativity suggested by the creativity and character-building curriculum. In short, this study assumes the internal structure of creativity to be multifaceted and hierarchical, rather than linear (e.g., Lee et al., 2009; Lee & Lew, 2010).

Accordingly, the sub-factors of *creative thinking ability* used to measure divergent thinking are *fluency* (the ability to come up with diverse ideas), *flexibility* (the ability to think from multiple angles), *originality* (the ability to think differently from others), *imagination* (the ability to think novel and imaginative thoughts), *sensitive thinking* (the ability to compare the new with the preexisting and be acutely observant), and *elaboration* (the ability to be specific and view theories as evidence). Likewise, *creative personality* is defined by and composed of *curiosity* (to be always inquisitive when observing), *sensitive personality* (to be mindful and attentive when observing an object or phenomenon), *task commitment* (willingness and effort to accomplish a task), *humor* (to handle an awkward or vague situation good-naturedly), *independence/bravery*, and *problem-solving leadership* (to lead in a manner that encourages all members to solve a problem creatively).

In accordance with the considerations of earlier research and theoretical studies, the K-ICT (Lee, 2014) was modified and developed as a multiple-choice test for ease of administration to college students. This study aimed to develop this test as a reliable and valid measuring tool that is not only internally consistent but also structurally valid.

Method

The purpose of this study was to develop and validate an objective integrated creativity test to reliably, reasonably, and easily measure college students' creativity. Therefore, after its development, the test was administered to college students to verify its validity as a measuring tool.

Research participants

Preliminary survey participants

To verify the test's validity, a preliminary survey was conducted among 775 students from "S" College in Seoul, Korea, who were taking a liberal arts class online. The results of the frequency analysis used to determine the participants' general characteristics are presented in Table 1.

Table 1. Demographic characteristics of participants.

		Frequency	Percentage
Age	under 25 years old	601	77.5
	over 25 years old	174	22.5
Gender	Male	381	49.2
	Female	394	50.8
Residential area	Seoul	431	55.6
	Gyeonggi and Metropolitan Area	287	37.0
	others	57	7.4
Major	liberal arts and social track	298	38.5
	physical sciences track	122	15.7
	physical sciences and IT track	355	45.8
Grade	1st	127	16.4
	2nd	181	23.4
	3rd	261	33.7
	4th	206	26.6
Total		775	100.0

Secondary main survey participants

Before performing a confirmatory factor analysis of the five factors each of creative thinking ability and creative personality derived from an exploratory factor analysis of the Simple Integrated Creativity Test (ICT-S), unfaithful or inappropriate responses to the preliminary survey were removed, leaving 666 that were included in the final analysis.

The results of the frequency analysis used to identify the participants' general characteristics are presented in Table 2.

Table 2. Descriptive statistics of participants.

		Frequency	Percentage
Age	1.0	512	76.9
	2.0	154	23.1
Gender	1.0	335	50.3
	2.0	331	49.7
Residential area	1.0	373	56.0
	2.0	245	36.8
	3.0	48	7.2
Major	1.0	243	36.5
	2.0	103	15.5
	3.0	320	48.0
Grade	1.0	117	17.6
	2.0	146	21.9
	3.0	225	33.8
	4.0	178	26.7
Total		666	100.0

Development of items for the multiple-choice Simple Integrated Creativity Test

Research procedure

In the first stage, multiple-choice measurement items were developed based on Lee's (2014) K-ICT. The creativity test developed in this study is an integrated one that comprises both creative thinking ability and characteristics, and can be taken online as well as offline. Since the existing test is standardized and its reliability and validity have been verified, it was used after some restructuring in consideration of the limitations of online tests. After creativity specialists verified the validity of the test several times, initial items were developed and used for preliminary testing. In the second stage, the item response bias and internal consistency of the test were verified for the data collected from the test takers, and its validity and reliability were verified by examining the correlations between sub-factors and conducting exploratory factor analysis. In the third stage, confirmatory factor analysis was conducted to verify the validity of the final model of the creativity measuring tool, and multiple group analysis was then carried out to confirm cross-validity.

Construction of preliminary test questions

The K-ICT utilized in this study comprises two main domains, creative thinking ability and creative personality, which are broken down to test 12 sub-factors. To test creative thinking ability, there are five activity questions that assess the six sub-factors of fluency, flexibility, originality, imagination, sensitive thinking, and elaboration; to test creative personality, there are 30 questions that evaluate the six sub-factors of curiosity, sensitive personality, task commitment, humor, independence/braveness, and problem-solving leadership. Table 3 presents the composition of the questions evaluating creativity.

Table 3. The composition of the K-ICT creativity test questions.

Domains	Sub-factors	Score range	Item number	Measurement time
creative thinking ability	fluency	0–10	activity1, activity 4	activity 1 = 5 minutes activity 2 = 7 minutes activity 3 = 5 minutes activity 4 = 3 minutes activity 5 = 5 minutes
	elaboration	0–10	activity 1, activity 2	
	imagination	0–10	activity 2, activity 3	
	flexibility	0–10	activity 4, activity 5	
	sensitive thinking	0–10	activity 3, activity 5	
	originality	0–10	activity 2, activity 5	
	Total	0–60		25 minutes
creative personality	curiosity	30–150	1, 11, 18, 24, 25	10 – 20 minutes
	sensitive personality		6, 8, 16, 23, 26	
	task commitment		7, 9, 15, 22, 27	
	humor		3, 5, 12, 21, 28	
	independence/bravery		4, 13, 17, 20, 29	
	problem solving leadership		2, 10, 14, 19, 30	

Data analysis

The data collected in this study were analyzed using SPSS and the Amos 22.0 program as follows. First, frequency analysis was conducted to determine the participants' demographic characteristics. Second, the mean, standard deviation, skewness, and kurtosis were calculated through the descriptive statistics of the measuring tool. Third, Cronbach's α coefficient was calculated to verify the internal consistency of the measuring tool and exploratory factor

analysis was performed to confirm the validity of the factorial structure. Principal axis factoring was used to extract factors, and then oblique rotation using the oblimin method, which assumes correlations among factors, was carried out ($\delta = 0$). To determine the suitability of the correlation matrix in factor analysis, the KMO (Kaiser-Meyer-Olkin) scale test and Bartlett's test were performed. When selecting the number of factors, those that had eigenvalue above 1 in relation to the scree plot were deemed appropriate. A factor with a coefficient above 0.4 and cross-factor loading value above 0.2 was considered to have appropriate correlation with the pertinent factor.

Fourth, Pearson's correlation coefficient was calculated to investigate the correlations in the factorial structure. Fifth, confirmatory factor analysis was carried out on the measurement model to demonstrate the construct reliability, discriminant validity, and convergent validity of the factorial structure. Structural equation modeling (SEM) tests whether there is a difference between a theoretical model and data-based research model by estimating parameters through the maximum likelihood method. By applying RMSEA (Root Mean Square Error of Approximation), one of the values of absolute fit indices that show overall suitability of a model, and NFI (Normed Fit Index), IFI (Incremental Fit Index), TLI (Tucker and Lewis Index), and CFI (Comparative Fit Index) for incremental fit indices, the fit between covariance matrices of the model and samples was evaluated.

Sixth, to verify the cross-validity of the measuring tool, its stability among groups was established by presenting consistencies in models of invariance constraint by groups. In other words, the following models were constructed first: the configural invariance model, where there are no constraints between models; the metric invariance model, where all factorial coefficients are constrained to be identical; and the scalar invariance model, with the constraint of equal factorial covariance. At each stage, differences in chi-square and the overall fit index were compared with those from the prior stage.

Results

Verifying the reliability and validity of the preliminary creativity test

Reliability of the preliminary test

A preliminary test was constructed to develop a multiple-choice creativity test, for which Cronbach's α was calculated to verify the internal consistency of the measuring tool; the findings are shown in Table 4.

Table 4. Reliability analysis of preliminary creativity test (Cronbach's α).

Domain	Factor	Question number	Cronbach's α		
creative thinking ability	fluency	3	.887	.779	.805
	elaboration	2	.610		
	imagination	2	.399		
	sensitive thinking	3	.702	.641	
	flexibility	2	.329		
	originality	2	.667		
creative personality	curiosity	4	.724	.873	.896
	sensitive personality	4	.581		
	task commitment	3	.637		
	problem solving	2	.497		
	humor	4	.776		
	independence	3	.707		

Validity of the preliminary test

To validate the ICT-S, exploratory factor analysis was performed on 14 questions of the six sub-factors of creative thinking ability and 20 questions of the six sub-factors of creative personality.

Principal axis factoring was used to extract factors, and oblique rotation using the oblimin method was carried out ($\delta = 0$). The KMO scale test and Bartlett's test were performed to determine the fit of correlation matrices in factor analysis. When selecting the number of factors, those that had eigenvalue above 1 in relation to the scree plot were deemed appropriate. A factor with a coefficient above 0.4 and cross-factor loading value above 0.2 was considered to have appropriate correlation with the pertinent factor.

The results of exploratory factor analysis for creative thinking ability are presented in Table 5.

Table 5. Exploratory factor analysis result of creative thinking ability.

	Factor	Item	fluency	sensitive thinking	originality	imagination	elaboration	flexibility	공통성
Creative thinking ability	fluency	Fluency1	.680	.037	−.001	−.130	−.005	.051	.603
		Fluency2	.955	.013	.008	.059	−.014	−.026	.852
		Fluency3	.895	−.037	.005	.048	.024	.005	.768
	elaboration	elaboration 1	.084	.039	−.012	−.102	.525	.033	.370
		elaboration 2	−.022	.014	.014	−.037	.765	−.062	.579
	imagination	imagination 1	.043	.037	.099	−.506	.041	.073	.366
		imagination 2	.158	.115	−.001	−.632	.272	.026	.730
	sensitive thinking	sensitive thinking1	.001	.641	.027	.223	.109	−.048	.493
		sensitive thinking2	.033	.693	.080	−.208	−.070	−.018	.572
		sensitive thinking3	.009	.644	−.057	−.069	.008	.072	.459
	flexibility	flexibility1	.068	−.020	.046	−.105	−.104	.443	.264
		flexibility2	.025	.120	.030	.167	.317	.455	.448
	originality	originality1	.055	−.027	.763	.010	−.033	−.085	.565
		originality2	−.054	.032	.659	−.020	.041	.108	.489
		Eigenvalue	3.133	2.352	1.592	1.668	2.005	1.286	
		explained variance %	28.107	10.302	6.611	3.807	2.900	2.271	
		cumulative variance %	28.107	38.409	45.020	48.827	51.727	53.998	

KMO = .821
Bartlett's test = 3556.597, $p < 0.001$

The KMO test value was 0.821, which is higher than the suitability criterion of 0.7 for the correlation matrix, indicating the fitness of the correlation matrix of items measuring creative thinking ability to factor analysis. The value of Bartlett's test was also significant and showed the fit of the correlation matrix ($p < .001$).

The three items on fluency, two on elaboration, two on imagination, three on sensitivity, and two on originality loaded validly onto their respective factors. The range of factor coefficients was between the absolute values .506 and .895. On the other hand, the load value of the second item on flexibility was below 0.2, indicating invalidity; hence, it was deleted. Since a single item cannot be a factor when constructing a confirmatory factor analysis model, flexibility was removed from the original structure of six factors for creative thinking ability, using the remaining five for analysis. All factors' eigenvalues were above 1, and the cumulative variance ratio was 53.998%.

The results of exploratory factor analysis for creative personality are shown in Table 6.

Table 6. Exploratory factor analysis result of creative personality.

	Factor	Item	curiosity	humor	task commitment	independence	sensitive personality	problem solving	공통성
creative personality	curiosity	curiosity 1	.589	.030	.049	-.155	.097	.042	.475
		curiosity 2	.510	.045	.115	-.056	-.176	-.160	.455
		curiosity 3	.638	.141	-.042	-.109	-.079	-.108	.570
		curiosity 4	.484	.002	.016	-.007	-.075	.183	.462
	sensitive thinking	sensitive thinking 1	.181	.098	.051	-.033	.115	.213	.148
		sensitive personality 2	.325	-.049	.168	.000	-.220	.109	.336
		sensitive personality 3	.135	.091	.032	-.007	-.481	.057	.452
		sensitive personality 4	.022	-.001	.133	-.176	-.618	.039	.607
	task commitment	task commitment 1	.163	-.158	.542	-.063	.018	.153	.440
		task commitment 2	.003	.116	.407	.115	-.060	.066	.232
		task commitment3	−.068	.044	.801	-.125	-.044	-.126	.667
	humor	humor 1	−.089	.329	.096	-.261	-.005	.197	.357
		humor 2	.143	.619	-.034	-.090	.016	-.031	.487
		humor 3	−.029	.721	.022	-.021	-.038	.016	.552

	humor 4	.006	.819	.027	.073	.012	.060	.684
independence	independence 1	.120	.037	.195	-.542	.003	-.077	.488
	independence 2	.066	.093	-.028	-.531	-.069	-.086	.380
	independence 3	−.011	-.040	-.034	-.755	-.035	.105	.571
problem solving	problem solving 1	−.073	.138	.107	.005	-.073	.500	.377
	problem solving 2	.176	.133	-.044	-.143	-.220	.346	.429
	Eigenvalue	3.626	3.237	2.741	3.259	2.267	1.712	
	explained variance%	27.656	6.393	4.498	2.883	1.785	1.620	
	cumulative variance%	27.656	34.049	38.547	41.430	43.215	44.836	
KMO = .894 Bartlett's test = 4629.481, $p < 0.001$								

The KMO test value was 0.824, which is higher than the suitability criterion of 0.7 for the correlation matrix, and it indicates the fitness of the correlation matrix of items measuring creative personality to factor analysis. The value of Bartlett's test was also significant and showed the suitability of the correlation matrix ($p < .001$).

Four items on curiosity, three on task commitment, and three on independence all loaded validly onto their respective factors. The range of factor coefficients was between the absolute values .401 and .801. However, the coefficients of Items 1 and 2 on sensitivity either fell short of 0.4 or had cross-factor loading values below 0.2. Similarly, the cross-factor loading values of Item 1 on humor and Item 2 on problem solving were below 0.2. Hence, Items 1 and 2 on sensitivity, Item 1 on humor, and Item 2 on problem solving were deleted. Since a single item cannot be a factor when constructing a confirmatory factor analysis model, as seen in the case of problem solving, it was removed from the original six factors constituting creative personality, and the remaining five were used for analysis. All factors' eigenvalues were above 1, and the cumulative variance ratio was 44.836%.

Reliability of the final creativity test

After developing the preliminary test and verifying its validity, the findings served as a foundation for once again determining the measuring capacity of the final creativity test. The reliability of the test's final items is presented in Table 7.

Table 7. Composition and reliability of creativity test (Cronbach's α).

Domain	Factor	Item number	Cronbach's α		
creative thinking ability (12 items)	fluency	3	.887	.779	.809	.877
	elaboration	2	.610		
	imagination	2	.399		
	sensitive thinking	3	.702	.627		
	originality	2	.667		
creative personality (15 items)	curiosity	4	.724	.851		
	sensitive personality	2	.636			
	task commitment	3	.637			
	humor	3	.783			
	independence	3	.707			
Total		27 items				

Confirmatory factor analysis of the creativity measuring tool

SEM verifies whether there is a difference between a theoretical model and a data-based research model by estimating parameters through the maximum likelihood method. By applying RMSEA, one of the absolute fit indices that show overall fitness of a model, and NFI, IFI, TLI, and CFI for incremental fit indices, the fit between the covariance matrices of the model and samples was evaluated. Table 8 illustrates the fit between the theoretical and competing models.

Table 8. Comparison of the fitness between the research model and the competition model of the Simple Integrated Creativity test.

	χ^2	*df*	NFI	IFI	TLI	CFI	RMSEA
Model 1: 1 Factor Model	1005.853	314	.846	.889	.875	.888	.058
Model 2: second-order factor model	765.314	313	.883	.869	.918	.927	.047
Model 3: third-order factor model	765.314	313	.883	.869	.918	.927	.047
	recommended standard		>0.9	>0.9	>0.9	>0.9	<0.08

In the one-factor model, where all sub-factors can be explained by the umbrella concept of creativity, χ^2 = 1005.853, and the values for NFI, IFI, TLI, CFI, and RMSEA were 0.846, 0.889, 0.875, 0.912, and 0.058, respectively (refer to Figure 1). In the hierarchical second-order factor model that allows covariance between the competencies of creative thinking ability and creative personality, χ^2 = 765.314, and the values of NFI, IFI, TLI, CFI, and RMSEA were 0.883, 0.869, 0.918, 0.927, and 0.047 (refer to Figure 2). Last, as an equivalent to the hierarchical second-order factor model, the hierarchical third-order factor model that explains the competencies of creative thinking ability and creative personality through creativity displayed identical fitness (refer to Figure 3). Therefore, the hierarchical second-order and third-order factor models showed higher fit to the data than the one-factor model, and were deemed to fit the theoretical model.

Figure 1. One-factor model (Model 1).

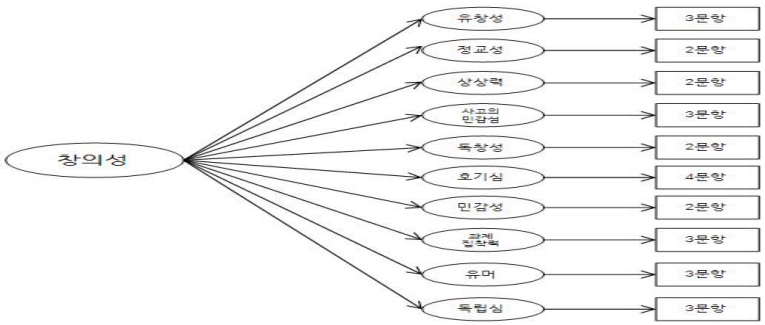


Figure 2. Hierarchical second-order factor model (Model 2).

Figure 3. Hierarchical third-order factor model (Model 3).

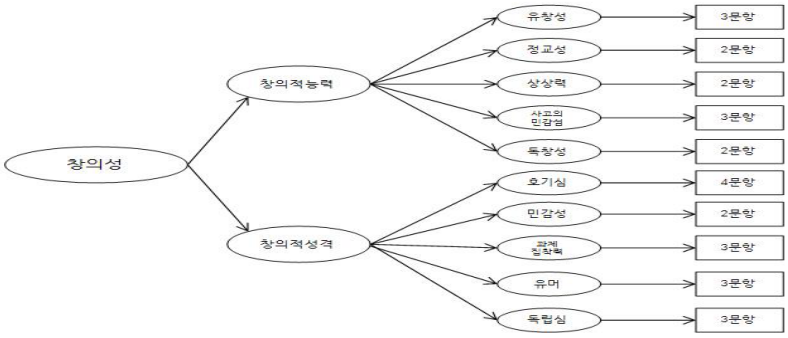
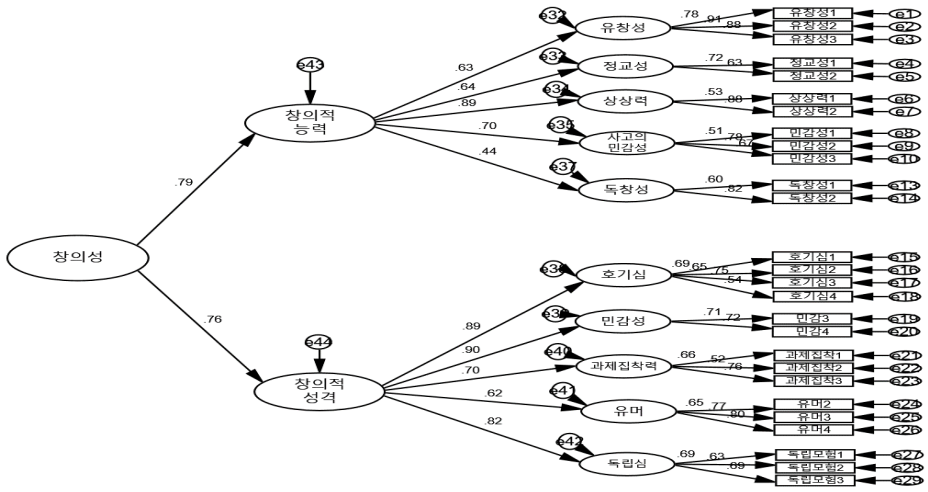


Figure 4. Factorial structure model of the Simple Integrated Creativity Test (standardized coefficient).



Parameter estimations derived from confirmatory factor analysis are shown in Table 9.

Table 9. Parameter estimate of the Simple Integrated Creativity test.

			B	S.E.	C.R.	β
creativity	creative thinking ability	fluency	1			0.635
		elaboration	0.877	0.097	9.082***	0.638
		imagination	1.019	0.117	8.678***	0.89
		sensitive thinking	0.642	0.076	8.497***	0.7
		originality	0.566	0.099	5.728***	0.439
	creative personality	curiosity	1			0.886
		sensitive personality	0.949	0.074	12.861***	0.898
		task commitment	0.763	0.073	10.462***	0.695
		humor	0.736	0.072	10.18***	0.621
		independence	1.098	0.09	12.145***	0.821
creative thinking ability	fluency	fluency 1	1			0.777
		fluency 2	1.283	0.052	24.668***	0.907
		fluency 3	1.219	0.051	24.142***	0.877
	elaboration	elaboration 1	1			0.717
		elaboration 2	0.778	0.084	9.221***	0.631
	imagination	imagination 1	1			0.526
		imagination 2	1.505	0.136	11.042***	0.88
	sensitive thinking	sensitive thinking 1	1			0.511
		sensitive thinking 2	1.446	0.133	10.887***	0.777
		sensitive thinking 3	1.241	0.117	10.594***	0.667
	originality	originality 1	1			0.601
		originality 2	1.363	0.205	6.643***	0.817
creative personality	curiosity	curiosity 1	1			0.69
		curiosity 2	1.069	0.075	14.28***	0.646
		curiosity 3	1.195	0.074	16.108***	0.751
		curiosity 4	0.754	0.062	12.13***	0.538
	sensitive	sensitive	1			0.707

personality	personality 3 sensitive personality 4	1.001	0.068	14.756***	0.716
	task commitment 1	1			0.659
task commitment	task commitment 2	0.81	0.076	10.612***	0.519
	task commitment 3	1.151	0.089	12.98***	0.764
	humor 2	1			0.646
humor	humor 3	1.064	0.071	14.986***	0.773
	humor 4	1.067	0.071	15.112***	0.8
	independence 1	1			0.693
independence	independence 2	0.928	0.07	13.191***	0.631
	independence 3	0.946	0.067	14.085***	0.692

The standardized coefficients of all sub-factors of creative thinking ability and creative personality were in the range .511–.907 and deemed stable. Since the coefficients for imagination and sensitive thinking of creative thinking ability, and curiosity and task commitment of creative personality were near 0.5, CR (construct reliability) and AVE (average variance extracted) values were examined to verify whether they hindered the validity of the factorial structure.

It is possible to verify whether measurement items, which are the observed variables in a measurement model, properly reflect relevant factors through their reliability and validity. To demonstrate factorial structure reliability and discriminant/convergent validity, the below process was carried out based on the Fornell and Larcker (1981) criterion.

(1) Verifying the significance of each unstandardized coefficient.
(2) Verifying whether standardized coefficients, which indicate the effect of latent variable on observed variable, are greater than 0.7.
(3) Verifying whether CR is greater than 0.7 to substantiate reliability.

(4) Verifying whether AVE, which indicates convergent validity, is greater than 0.5.
(5) To determine the discriminant validity, verifying whether correlation coefficients among factors are less than the square root of AVE.

Table 10 presents the correlation coefficients among the measuring tool's factors, CR, the square root of AVE, and Cronbach's α coefficient.

Table 10. Correlation matrix and C.R., AVE of factors

	factors	fluency	elaboration	imagination	sensitive thinking	originality	curiosity	sensitive personality	task commitment	humor	independence
CTA	fluency	.832									
	elaboration	.293**	.709								
	imagination	.481**	.339**	.778							
	sensitive thinking	.257**	.439**	.333**	.723						
	originality	.274**	.051	.280**	.199**	.737					
CP	curiosity	.301**	.146**	.343**	.273**	.277**	.709				
	sensitive personality	.232**	.139**	.304**	.269**	.227**	.586**	.782			
	task commitment	.205**	.098*	.213**	.239**	.137**	.435**	.446**	.712		
	humor	.280**	.160**	.367**	.243**	.234**	.421**	.408**	.323**	.767	
	independence	.234**	.073	.339**	.230**	.245**	.546**	.489**	.383**	.414**	.708
	CR	.871	.669	.743	.762	.699	.799	.758	.751	.809	.751
	AVE	.693	.503	.606	.523	.544	.502	.611	.507	.588	.501
	Cronbach's α	.888	.620	.631 .811	.699	.658 .885	.748	.672	.681 .870	.772	.711

**$p < 0.01$, Note: diagonal line is the AVE square root

The CR values for the sub-factors of creative thinking ability were between .669 and .871, and

those for creative personality were between .751 and .809. The values were either near or greater than 0.7. The AVE value, indicating convergent validity, was in the range .503–.693 for creative thinking ability and .501–.611 for creative personality, indicating that all values exceeded 0.5. Furthermore, the square root of AVE exhibited higher values than the correlation coefficients among factors, signifying the discriminant validity of the factorial structure. Through the above analysis, the reliability and validity of K-ICT-S have been proven.

Cross-validity verification of the creativity measuring tool

The cross-validity between major groups was investigated. Three models were sequentially set—the configural invariance model where there are no constraints between models, metric invariance model where the constraint is that all factorial coefficients are identical, and scalar invariance model with the constraint of equal factorial covariance. Then, for each stage, the differences in chi-square and the overall fit index were compared with those from the prior stage. Only after it is verified that there are no changes in either of the values can the measuring tool be presented as valid among groups. Table 11 presents the analysis results.

Table 11. Verification of differences in invariance constraint by major.

Group		χ^2	*df*	CFI	NFI	IFI	TLI	RMSEA	Sig.
Major	Configural Invariance	1570.674	939	.901	.789	.903	.889	.032	
	Metric Invariance	1599.146	973	.902	.785	.903	.894	.031	$\Delta\chi^2 = 28.472$ $df = 34, p > 0.05$
	Scalar Invariance	1603.882	975	.901	.784	.903	.894	.031	$\Delta\chi^2 = 4.736$ $df = 2, p > 0.05$

The chi-square difference between the configural invariance model and metric invariance model was calculated to be insignificant $(\triangle\chi^2(34) = 28.472, p > 0.05)$, and there were little differences in the fit as well (△CFA = −.001, △NFI = −.004, △IFI = 0, △TLI = .005, △RMSEA = −.001). Furthermore, the chi-square difference between the metric invariance model and scalar invariance model was found to be insignificant $(\triangle\chi^2(2) = 4.736, p > 0.05)$, and there were hardly any differences in the fit as well (△CFA = −.001, △NFI = −.001, △IFI = 0, △TLI = 0, △RMSEA = 0). Ultimately, the factorial structure among groups was determined to be stable, and the cross-validity of the creativity measuring tool by major was confirmed.

Conclusion

This study aimed to develop and verify the validity of the Korean Simple Integrated Creativity Test (K-ICT-S) to easily measure the creative thinking ability and creative personality of Korean college students. Accordingly, the finalized K-ICT-S was completed, consisting of items that have been verified for reliability and validity; it can comprehensively measure creative thinking ability (12 items) and creative personality (15 items). Creative thinking ability is designed to measure *fluency*, *elaboration*, *imagination*, *sensitive thinking*, and *originality*, while creative personality is designed to measure *curiosity*, *sensitive personality*, *task commitment*, *humor*, and *independence*.

The majority of creativity tests targeting college students and adults developed and used so far measure creative personality or tendencies. While performance ability should be evaluated to validly measure creative ability, it has been accompanied by scoring problems and executional difficulties in implementing group tests for college students or adults. Therefore, the current test was developed for collective application to comprehensively measure creative thinking ability and creative personality in college students and adults while being easily scored and coded. As this test addresses and resolves obstacles to conducting creativity tests for college students and adults, it may thus be widely used as a convenient measuring tool at creativity testing sites.

In particular, the enhancement of creative competency in future talents has recently received increasing attention from universities and corporations—universities are developing relevant curriculums, while corporate human resource development centers are creating training programs. The test developed in this study can contribute to both.

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