Research Article

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Creativity: Influencing Factors on Student Innovation and Creativity Skills in the Design of Industrial Products

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Abstract

The objective of this research was to study the influencing factors related to the creativity and innovation skills of students in the field of industrial product design, and the population was defined as three hundred and nine students in the product design program at King Mongkut's Institute of Technology Ladkrabang with the sample group comprising two hundred and seventy-five 1st–4th year students selected using stratified sampling. Additionally, structured interviews were used as the research tool (Cronbach's alpha = 0.803), which was analyzed by Exploratory Factor Analysis and Confirmatory Factor Analysis. In this case, it was found from the EFA analysis that there were three components (KMO = 0.950): 1) the fundamental component of self-concept, 2) the consideration of the impact on others, and 3) the drive component that stimulates development, with the goodness of fit index as follows: χ^2 = 22.202, df = 26, relative χ^2 = .854, p-value = .678, RMSEA = .000, RMR = .010, GFI = .985, AGFI = .963, NFI = .994, TLI = 1.002, PGFI = .388, RFI = .987, AIC = 102.202. In this study, the composition from EFA was shown to be consistent with the CFA by having a structural equation model with a measurement model that fits well with the theoretical model of stimulating creativity and innovation. Moreover, it corresponds to the empirical data at a good level with the following values: χ^2 = 19.964, relative χ^2 = .768, p-value = .795, RMSEA = .000, GFI = .987, CFI = 1.000.

Keywords: *Creativity, Innovation, Structural Validity, Goodness of fit Index*

1. Introduction

Due to the sudden changes in the 21st century, the world has experienced events that have changed the way of life of every human being on earth, namely: 1) the spread of COVID-19, 2) the war between Russia and Ukraine, 3) the global economic recession, and 4) the occurrence of the 4th Industrial Revolution, with all four factors affecting the way of life of human beings in the present and future eras by causing changes that differ from the past. As a result, human needs in the 21st century have become more complex and thus, the needs of modern humans are difficult to understand. Thus, the creation of products to meet their needs is more complicated than in the past, and there are many factors that collectively affect the purchasing decisions of modern consumers.

Therefore, this situation is involved with the encouragement of students to study at the higher education level in order to appropriately develop creative skills that can be applied to life in the 21st century. Moreover, the creative skills are important for the new generation of students while

creativity is thought to be the result of the integration of flexible thinking skills together with systematic thinking skills. Thus, this is the combination of thinking outside the box with thinking inside the box, especially with regard to creative thinking abilities that are important to students who are studying in the product design courses. Additionally, it is also an intellectual skill that can help to predict the direction of product design congruently with the needs of modern humans, and the creativity skills are thinking skills that must be conveyed to the new generation of students in order for them to be able to produce innovations to meet the needs of modern humans. Therefore, thinking skills in the primary forms that were used in the past may not be able to be applied effectively to meet human needs in the future, (Al-Shaikh and Najeh, 2023).

The development of knowledge to enhance creativity in students is considered to be the development of highly efficient product design personnel with the capacity for the creation of the innovations suitable for the 21st century. For students to be able to respond to the ways of life and human needs appropriately, this research studies the factors affecting learning in innovation and creativity among design students. Thus, the students can integrate the creation of products congruently with the situation in the 21st century, in order to achieve maximum positive outcomes for learners, (Richardson, 2022; Momani, 2023).

2. Objectives

To study the factors that influence the creativity and innovation skills of the students in the Department of Design Education.

3. Research of Conceptual Framework

Attention Schema Theory (AST): The application of learners' traditional experiences can create more sustainable design knowledge by combining new knowledge with the original experience within the learners for creating innovative ideas within themselves.

1. Encourage the behavior that teachers want to occur in students.
2. Determine the students' behavior according to the needs of the teacher by providing reinforcement to the students, (Wang et al., 2022).

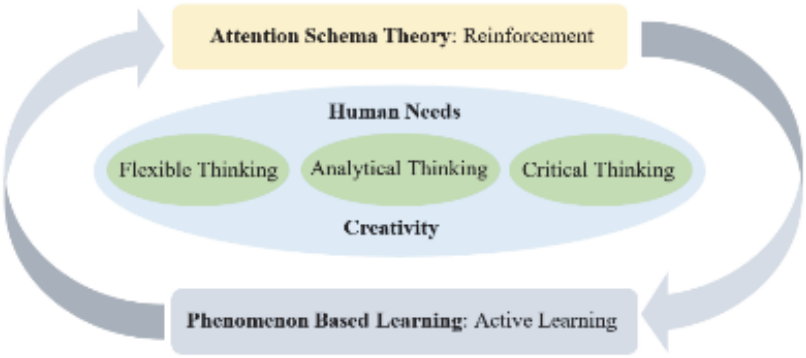


Fig. 1: Conceptual Framework for the Research
Source: Author

Creativity: The training to provide skills of diversified thinking will help to develop creativity, such as flexible thinking, critical thinking, and analytical thinking. Hence, these three types of thinking are the factors that can help to stimulate creativity, (Mohd et al., 2023; Alnaim, 2023).

4. Literature Review

According to the learning view of Attention Schema Theory (AST), the learners' minds can be encouraged to learn from the senses, memory and thought, (Wilterson and Graziano, 2021). Moreover, for the minds of learners to create wisdom that arises from self-understanding, there are two learning characteristics: 1) knowledge derived from the perceptions from the body's sensory system and 2) knowledge arising from perceptions of the mental process of cognition within the brain. Thus, these two forms of stimulation of perception will help the learners pay direct attention to that content, which is similar to applying the knowledge from previous experiences in oneself. In addition, it can be mixed with knowledge from the situation of their surroundings, which, when internal knowledge and external knowledge are mixed together, will create profound knowledge and long-term memory. In this case, the learners can apply these types of knowledge to predict future events appropriately, where creativity can be developed to predict the future if the learners are encouraged to demonstrate continuous creativity by giving them positive reinforcement.

This corresponds to the theory of motivation of psychoanalytic theories in which the aim is to create incentives to encourage positive behavior in student product design. Thus, it appropriately stimulates the learners to make creations with the aim of developing their skills by having fun while practicing creative thinking skills. Therefore, it is a stimulus created by the teacher to increase the students' feelings of wanting to learn, (Petrova, 2017).

Furthermore, this method was applied to help with the creation of the enthusiasm for learning and experimenting with product design. According to the learning method that creates practical activities for solving the problems in product design, the learners are allowed to gain experience in a trial and error manner until it becomes the knowledge that they are able to retain for a long time, including the altering of these experiences within the learner's brain at a future time, as mentioned in constructivist learning theory, (Børte et al., 2020; Hartikainen et al., 2019).

In this case, the creative skills are essential to the development of a student's product design profession in higher education, whereas the creativity can lead students to success in innovation. Moreover, based on the concept of the future where creativity does not come from talent, it will arise from the ability of individuals to combine the new knowledge with that from their own past experiences with invention and development, and the goal is to meet the needs of oneself and others, (Livingston, 2010; Egan et al., 2017; Miller and Dumford, 2016).

5. Methodology

Scope of the Study: The population is three hundred and nine students in the Bachelor of Industrial Education program in the Department of Product Design for every school year in the Faculty of Industrial Education at King Mongkut's Institute of Technology Ladkrabang.

Furthermore, the sample group included two hundred and seventy-five students in the Bachelor of Industrial Education program in the Department of Product design for every school year selected by using stratified sampling and the ready-made sampling table of Taro Yamane at a confidence level of 98%, (Yamane, 1973). Moreover, they are the students that presented the innovative works in the Academic Exhibition of King Mongkut's Institute of Technology Ladkrabang 2022.

In this study, the research tools are the structured interview as a questionnaire to be measured with a 5-point Likert Rating Scale, (Cronbach's alpha = 0.803) and analyzed with mean, standard deviation, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), (Hair et al., 2006).

Table 1: Flexible Thinking, Analytical Thinking, and Critical Thinking

Attention Schema Theory: Reinforcement	Phenomenon Based Learning : Active	Creativity: Innovation
1) Describe the learning content. 2) Create learning by product design competition from problems assigned by teachers. 3) Motivate efforts with rewards. 4) A new type of product arising from systematic thinking within oneself.	1) On-the-job training from entrepreneurs in the workplace 2) Hands-on practice 3) Production of product prototypes and test use. 4) Bring product prototypes to market and exhibit at exhibitions.	1) Integration between theory and practice 2) Combination of Flexible Thinking , Analytical Thinking , Critical Thinking to meet human needs
Finding answers from studying in class	Finding answers from real practice	Creativity/Innovation

Source: Author

Fig. 2: 1) Creative Process of Students, 2) Sale of Self-Designed and Manufactured Products to Acknowledge Consumer Satisfaction
Source: Author

Table 2: Application of Basic Knowledge for Students' Creativity

Integrated Science	Characteristics of Applying Knowledge	Skill Assessment			
		[1]	[2]	[3]	[4]
Social Sciences	1) Understanding human needs	✓		✓	
	2) Understanding social conditions in the present time	✓		✓	✓
Economics	1) Understanding the direction of the product market	✓	✓		✓
	2) Perception of consumer needs	✓		✓	✓
Physiology	1) Understanding the physiology that affects product design	✓		✓	
	2) Sizing analysis of product users	✓	✓		✓
Psychology	1) Understanding the psychology of consumer arousal	✓			✓
	2) Understanding different personal needs	✓		✓	✓
Mathematics	1) Application of mathematics for decision making		✓	✓	✓
	2) Using mathematics to resolve conflicts in product design		✓	✓	
Thinking Skills	1) Independent and highly flexible thinking			✓	✓
	2) Systematic thinking	✓			
Creative Thinking	1) Integrating knowledge into product creation			✓	✓
	2) The beginning of innovation	✓	✓	✓	✓

[1] systematic thinking, [2] mathematical thinking, [3] flexible thinking, [4] applied thinking

Source: Author

6. Results

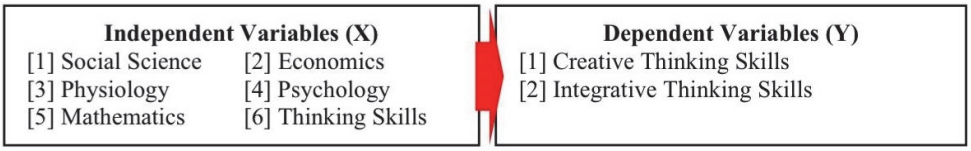
The results of the Normality Testing compiled from all two hundred and seventy-five sets of data with ten aspects of the criteria by considering for the skewness value and Kurtosis with a value less than +/-1 indicated that the data is complete in the analysis with parametric statistics.

Table 3: Results of Student Knowledge Application in Product Design and Normality Testing

Integration with science	Application of Knowledge	Examination of the Data Distribution (n = 275).					
		Mean	S.D.	Skewness		Kurtosis	
				Statistics	Std. Error	Statistics	Std. Error
Systematic thinking	Social Sciences	3.88	.977	-.600	.147	-.195	.293
	Economics	3.76	.936	-.499	.147	-.444	.293
	Physiology	3.79	.956	-.468	.147	-.558	.293
	Psychology	3.83	.931	-.356	.147	-.515	.293
Mathematical thinking	Mathematics	3.89	.977	-.576	.147	-.334	.293
	Thinking Skills	3.92	.943	-.505	.147	-.550	.293
Flexible thinking	Creative Thinking	4.04	.879	-.476	.147	-.573	.293
	Social skills	3.826	.826	-.616	.147	-.681	.293
Applied thinking	Statistical skills	3.983	.864	-.543	.147	-.564	.293
	Integrative Thinking Skills	3.850	.859	-.546	.147	-.447	.293

Source: Author

Table 4: Relationship Between Independent (X) and Dependent (Y) Variables



Source: Author

According to the analysis, the results were as follows: 1) Residual Mean = 0, 2) Normal Distribution Curve contains data below the normal distribution line and no out-of-bounds values in the analysis, 3) Independent variables and dependent variables have a linear relationship, and 4) Variables with equal variance were assumed by using a scatter plot with the arrangement of the data as the band slopes from the left corner to the right corner, and the data is without clutter.

Table 5: Multiple Regression Analysis Using Linear Regression

Model		Sum of Squares	Df	Mean Square	F	P-value
1	Regression	214.147	7	30.592	229.881	.000
	Residual	35.133	264	.133		
	Total	249.279	271			

Source: Author

ANOVA table with statistical significance (Sig. = .000) showing that the analyzed multiple regression equation has facts to be studied.

Table 6: Correlation Coefficients of Factors Affecting the Increase in Innovation Skills

Variable	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Innovation	1.000	-	-	-	-	-	-	-
[X1] Social Sciences	.753**	1.000	-	-	-	-	-	-
[X2] Economics	.750**	. 591 **	1.000	-	-	-	-	-
[X3] Physiology	.769**	. 594 **	.831**	1.000	-	-	-	-
[X4] Psychology	.812**	. 629 **	.724**	.771**	1.000	-	-	-
[X5] Mathematics	.779**	. 613 **	.695**	.695**	.748**	1.000	-	-
[X6] Thinking	.831**	. 628 **	.691**	.691**	.706**	.790**	1.000	-
[X7] Art	.875**	. 723 **	.759**	.760**	.783**	.756**	.801**	1.000
Mean	4.051	3.86	3.76	3.78	3.83	3.89	3.92	4.04
SD	.959	.976	.941	.961	.935	.981	.945	.881

** p < .01, [1] Innovation, [2] Social Sciences, [3] Economics, [4] Physiology, [5] Psychology, [6] Mathematics, [7] Thinking, [8] Art

Source: Author

Based on the results, the factors affecting the Innovation skills of students are as the following: 1] Social Sciences, 2] Economics, 3] Physiology, 4] Psychology, 5] Mathematics and 6] Thinking Skills. Therefore, all seven aspects of Art were significantly correlated at the 0.01 level with a correlation coefficient between .591–.875, and the variable with the highest correlation coefficient was Artistic knowledge and creative skills innovation, with a correlation coefficient of .875, followed by: 1) Knowledge of thinking skills and innovation skills, and 2) Knowledge of ergonomics and knowledge of economics with the correlation coefficient equal to .831, and the variable with the lowest correlation coefficient was Economic knowledge including social knowledge, with a correlation coefficient of .591.

Table 7: Results of Stepwise Multiple Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	-.179	.108		-1.649	.100
	X1: Social Sciences	.183	.033	.187	5.481	.000*
	X2: Economics	.020	.046	.020	.439	.661
	X3: Physiology	.074	.047	.074	1.581	.115
	X4: Psychology	.195	.045	.190	4.373	.000*
	X5: Mathematics	.040	.042	.041	.948	.344
	X6: Thinking	.256	.045	.253	5.732	.000*
	X7: Art	.312	.055	.287	5.638	.000*
R = 0.927, R^2 = 0. 859, Adj R^2 = 0.855, SEE = 0.366, Durbin-Watson = 1.789, * p < . 01						

Source: Author

According to the analysis, the results were as follows: 1) Social Sciences (β =.183, t = 5.481, *p*-value = .000), 2) Psychology (β = .195, t = 4.373, *p*-value = .000), 3) Systems Thinking (β = .256, t = 5.732, *p*-value = .000), and 4) Art (β = .312)., t = 5.638, *p*-value = .000). Therefore, all four knowledge factors affect the innovation skills, with statistical significance at .01, from economics (β = .020, t = .439, *p*-value = .661), physiology (β = .074, t = 1.581,p-value = .115) and mathematics (β = .040, t = .948, *p*-value =

.344). Thus, these three factors of knowledge did not affect the increase in innovation skills, with statistical significance at .01.

- Regression equation in raw score form is as the following:

$\hat{y} = -.179 + .183(X_1) + .195(X_4) + .256(X_6) + .312(X_7)$

- Regression equation in standard score form is as the following:

$Z = .187(X_1) + .190(X_4) + .253(X_6) + .287(X_7)$

Moreover, the process of identifying elements is important to the development of creativity and innovation in students who were selected to present their product design and work at the Innovation Exhibition of King Mongkut's Institute of Technology Ladkrabang.

In this case, the researcher used Exploratory Factor Analysis, which is classified as the components of the factors.

Table 8: Data Analysis of the Variables in the Research

Side potential	Mean	S.D.	Potential student	Communalities Extraction	Anti-image Correlation Matrices	Normality Testing	
						Skewness	Kurtosis
[1] Social Sciences	3.88	.977	high level	.958	.902[a]	-.600	-.195
[2] Economics	3.76	.936	high level	.889	.931[a]	-.499	-.444
[3] Physiology	3.79	.956	high level	.889	.949[a]	-.468	-.558
[4] Psychology	3.83	.931	high level	.778	.965[a]	-.356	-.515
[5] Mathematics	3.89	.977	high level	.803	.972[a]	-.576	-.334
[6] Thinking	3.92	.943	high level	.870	.954[a]	-.505	-.550
[7] Creativity	4.04	.879	high level	.854	.964[a]	-.476	-.573
[8] Art	4.03	.988	high level	.877	.967[a]	-.625	-.614
[9] Motive	3.88	1.04	high level	.907	.910[a]	-.622	-.775
[10] Growth Mindset	4.02	.941	high level	.884	.959[a]	-.474	-.920
[11] Innovation	4.06	.958	high level	.884	.960[a]	-.553	-.740

a; Measures of Sampling Adequacy (MSA)

Source: Author

According to the communality values extraction, the ability of each variable is formed as a factor appearing between .778–.958, which is greater than .5 and has a value close to 1. Therefore, all eleven variables can be considered as a factor.

Table 9: Correlation Matrix of Research Variables

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Social Sciences	1.000	-	-	-	-	-	-	-	-	-	-
Economics	.590*	1.000	-	-	-	-	-	-	-	-	-
Physiology	.593*	.831*	1.000	-	-	-	-	-	-	-	-
Psychology	.622*	.722*	.770*	1.000	-	-	-	-	-	-	-
Mathematics	.604*	.693*	.693*	.749*	1.000	-	-	-	-	-	-
Thinking	.628*	.691*	.691*	.704*	.787*	1.000	-	-	-	-	-
Creativity	.720*	.758*	.759*	.781*	.754*	.802*	1.000	-	-	-	-
Art	.639*	.723*	.715*	.764*	.798*	.849*	.830*	1.000	-	-	-
Motive	.804	.788*	.756*	.706*	.666*	.662*	.745*	.694*	1.000	-	-
Growth Mindset	.622*	.703*	.700*	.738*	.805*	.845*	.833*	.850*	.660*	1.000	-
Innovation	.756*	.748*	.767*	.805*	.771*	.829*	.872*	.833*	.783*	.815*	1.000

* p < .01

Source: Author

The correlation value is between .590–.850, which is close to 1; thus, it is considered that the data of each of the eleven variables are highly correlated and have Sig. < .01 for all variables, indicating that all eleven variables were suitable for EFA analysis.

Additionally, according to KMO and Bartlett's Test of the sample with Kaiser-Meyer-Olkin, it was measured that Sampling Adequacy = .950, Df = .000, Approx. Chi-Square = 3603.427 and Sig. = .000. Therefore, all results were in accordance with the specified criteria.

Table 10: Total Variance with Research Variables

	Initial Eigen Values			**Rotation Sums of Squared Loadings**			**Extraction Sums of Squared Loadings**		
	Total	[A]	[B]	Total	[A]	[B]	Total	[A]	[B]
1	8.437	76.699	76.699	8.437	76.699	76.699	4.401	40.012	40.012
2	.649	5.901	82.601	.649	5.901	82.601	2.942	26.742	66.754
3	.517	4.696	87.296	.517	4.696	87.296	2.260	20.542	87.296
4	.291	2.650	89.946	[A] = % of Variance, [B] = Cumulative %					
5	.255	2.321	92.267						
6	.174	1.583	93.850						
7	.169	1.536	95.387						
8	.144	1.309	96.696						
9	.137	1.249	97.945						
10	.120	1.091	99.037						
11	.106	.963	100.000						
Total Variance Explained: Method for Extraction (Principal Component Analysis PCA)									

Source: Author

According to the total variance from the eleven observed variables, they can be classified into three factors with component weights as follows: the first factor is the most important, which explains the variance of the data at 40.012%, the second factor explains the variance of the data at 26.742%, and the third factor can explain the variance of the data at 20.542%.

Table 11: Component Weight Values After Axis Rotation by Varimax Method

Variables	**Indicative Characteristics of Innovation Creation**	**Factor 1**	**Factor 2**	**Factor 3**
Growth Mindset	Ready-to-learn with concepts and having continuous thinking development	.832	-	-
Thinking	Systematic thinking having a stepwise nature	.827	-	-
Art	The ability to perceive beauty and aesthetic value	.800	-	-
Mathematics	Applying numbers to in the process of creativity	.764	-	-
Creative	Independent thinking without limiting the solution to the problem.	.677	-	-
Innovation	Integrative thinking that fosters innovation that is different from the past	.664	-	-
Physiology	Systematic thinking regarding organs and the size of the human body.	-	.809	-
Economics	Systematic thinking with regard to economic worth	-	.801	-
Psychology	Systematic thinking related to psychology and the feelings that occur within the mind	-	.592	-
Social Sciences	Thinking that takes into account social and environmental conditions.	-	-	.881
Motive	Need for success	-	-	.682

Source: Author

Factor 1: Fundamental factors of self-concept consisting of six variables that have the potential to affect the number of variables; namely, growth mindset, thinking, art, mathematics, creativity and innovation, which have weight components of .832, .827, .800, .764, .677 and .664, respectively.

Factor 2: The factor of considering the impact on others consisting of three variables that have the potential to have an effect; namely, physiology, economics and psychology, which have the component weights of .809, .801 and .592, respectively.

Factor 3: The factor that drives development consisting of two variables that have a chance to affect the number of variables with social sciences and motive, which have the weight of the components equal to .881 and .682, respectively.

According to the steps of Confirmatory Factor Analysis (CFA), it can be confirmed that the components that were generated from the Exploratory Factor Analysis (EFA) have three factors that directly affect student innovation and creativity with the process as follows: 1) Confirmatory components, 2) Component weights, 3) Extractable variance values and 4) Reliability of Factor 1, Factor 2 and Factor 3, by which it is considered that the variable components of all three factors have reliability values and discriminate validity, (Hair, 2006; Sternberg, 2003).

Table 12: Component Weight Values of the Extracted Variance and the Reliability of the Three Factors

Observable variable	Internal Elements	Component Weight Value (> .30)	Average Extracted Variation (AVE) Average Variance Extraction	Trust Value (CR) Composite Reliability
Factor 1: Fundamental factors of self-concept	S1: Learning satisfaction	.89 6	0.81322 (≥ .50)	0.96311 (≥ .60)
	S2: Growing up	.923		
	S3: Arts	.927		
	S4: Creation	.890		
	S5: Thinking	.915		
	S6: Mathematics	.862		
Factor 2: The factor of considering the impact on others	A1: Economics	.883	0. 7781 (≥ .50)	0.9 129 (≥ .60)
	A2: Psychology	.818		
	A3: Ergonomics	.941		
Factor 3: Factors that drive development	M1: Social sciences	.838	0. 8109 (≥ .50)	0. 8951 (≥ .60)
	M2: Motive	.959		

Note: Statistical significance at .05

Source: Author

Insight checking of the newly created elements by examining the importance of each observed variable component, which prioritizes the new elements.

- First order analysis: Testing the measurement model from three factors affecting student creativity and innovation for analyzing the co-influence of each variable to observe the creation of innovation.

Table 13: First Order of Innovation and Creativity in Students

Latent variable / Observable variable	Self			Awareness			Motive			r^2
	β_i	b_i	SE	β_i	b_i	SE	β_i	b_i	SE	
Mathematics	.889	.965 **	. 044	-	-	-	-	-	-	. 791
Thinking	.875	.916 **	.038	-	-	-	-	-	-	. 766
Creativity	.928	.904 **	.031	-	-	-	-	-	-	. 861
Satisfaction	.941	1.000	-	-	-	-	-	-	-	. 885
Art	.892	.979 **	.038	-	-	-	-	-	-	. 796
Growth Mindset	.894	.934 **	.038	-	-	-	-	-	-	. 799
Economics	-	-	-	.845	.947**	.053	-	-	-	. 714
Physiology	-	-	-	.852	.974**	.050	-	-	-	. 726
Psychology	-	-	-	.897	1.000	-	-	-	-	. 805
Motive	-	-	-	-	-	-	.937	1.000	-	. 879
Social Sciences	-	-	-	-	-	-	.854	.847**	.045	. 729

Innovation Creativity latent variable	β_i	b_i	SE	R^2
Self	.973	1.000	-	.947
Awareness	.971	.925**	.047	. 942
Motive	.849	.950**	.050	. 721

* P < .05 ; ** P < .01

Source: Author

According to the second order confirmatory component analysis of the student innovation and creativity factor with the Amos program, there is an index to check the consistency of the model according to the Schumacker & Lomax criteria, (Schumacker and Lomax, 2010), which are χ^2= 22.202 , df = 26, relative χ^2= .854, p-value = .678, RMSEA = .000, RMR = .010, GFI = .985, AGFI = .963, NFI = .994, TLI = 1.002, PGFI = .388, RFI = .987, AIC = 102.202.

Moreover, it used the configured criteria of the consistency index, relative $\chi^2 < 2$, RMSEA and RMR < .05 and GFI, AGFI, NFI, TLI > .95 with AGFI value > .90 with all criteria meeting the concept of Diamantopoulos and Siguaw (2000) and in accordance with the concept of Kelloway (2015).

- Students' creativity and innovation factors consist of three components: (1) Elements of the fundamental factors of self-concept measured from six observed variables, which are S1 (mathematics), S2 (thinking), S3 (creation), S4 (satisfaction), S5 (art) and S6 (thinking growth), (2) the factors of considering the impact on others measured from three observational variables, namely A1 (economics), A2 (physiology) and A3 (psychology), and (3) the factors that drive development measured from two observed variables, which are M1 (Social Sciences) and M2 (Motive).

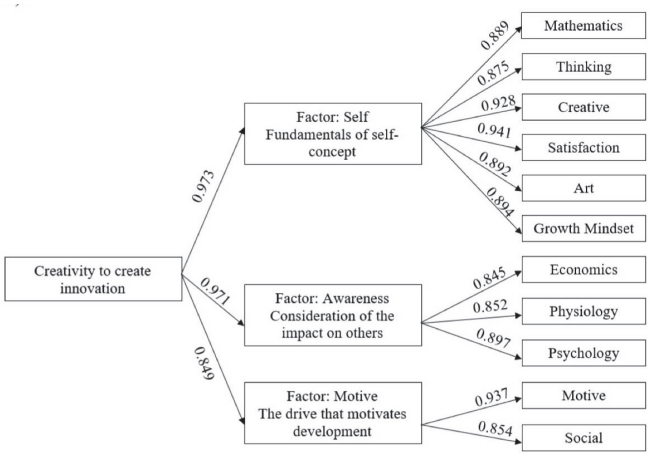


Fig. 3: Second Order of Innovation and Creativity Factors of Students
Source: Author

Checking for the measurement equations by use of the statistics of Standard Regression Weight, Standard Error, *p*-value and SMC. (R^2) of the following variables: (1) Factor 1: Fundamental factors of self-concept, (2) Factor 2: The factor of considering the impact on others, and (3) Factor 3: The factor that drives development.

- The results show the full model of the creative factors of students; it is the initial measurement model before subsequently adjusting the new measurement equation model.

Table 14: Consistency values of the measurement model of student creativity factors before adaptation and after measurement adjustment

Variable	X^2	X^2/df	df	p-Value	GFI	CFI	RMR	RMSEA	Interpret
[1] Before model adaptation	214.522	5.232	41	.000	.874	.952	.034	.124	Not Accepted
[2] After model adaptation	19.964	.768	26	. 795	. 987	1.000	.0 09	. 000	Accepted

Source: Author

According to the comparison of criteria for consideration, the ratio of chi-square and degree of freedom (X^2/df) < 3, *p*-value > .05, GFI and CFI >. 95, RMR < .05, RMSEA < .07 can be summarized as follows:
[1] Full model before model adaptation: the measurement model was inconsistent (model did not fit) with the theoretical model inducing creativity and innovation, (Weerawardena & O'Cass, 2004). Thus, it could be concluded that the measurement model does not conform to the theoretical model specified at an acceptable level, and the researcher then adjusted the model modification regarding the error in the estimation.

[2] Full Model after adjusting the model: the measurement model is consistent (model fit) with the theoretical model to stimulate creativity and innovation. Therefore, it can be concluded that the measurement model is consistent with the theoretical model defined at an acceptable level.

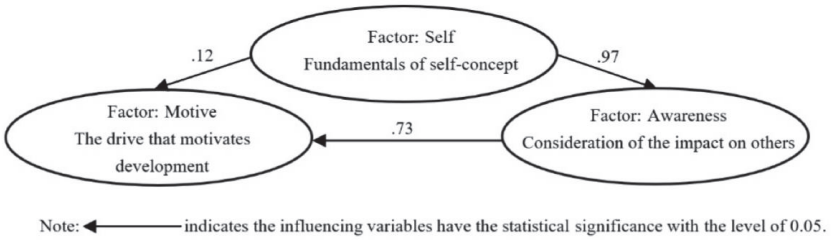


Fig. 4: Creativity Factor of Students Studying Design
Source: Author

The results from the elemental analysis of the creativity factors of design students consist of: 1) the fundamental factor of self-concept, 2) the factor of thinking about the impact on others, and 3) the driving factor that stimulates development.

It was found that the fundamental factors of self-concept have a direct influence on the factor of considering the impact on others, and it was the highest at the .97 level with a statistical significance at the .05 level, followed by the factor of considering the impact on others, which has a direct influence on the factor of driving development at the .73 level with a statistical significance at the .05 level. In this case, the fundamental factor of self-concept directly influences the factor driving development at the .12 level with statistical significance at the .05 level, sorted in descending order.
From the structural equations, it was found that creativity and innovation occurred with product design students, and it appears that the factors influencing creativity and innovation are the fundamental factors of self-concept, which is the basis of knowledge in the various sciences that students possess. Moreover, it is involved with the direct influences for considering the impact on others, until it becomes a driving force for development, which is an important goal that allows innovation to occur.

7. Conclusions

According to the results of the second order confirmatory factor analysis of the factors affecting creativity and innovation of students in the field of product design, the components created by the researcher were consistent with the empirical data. Moreover, it was shown that the factors that affect the emergence of creativity and innovation consist of three components: 1) Basic self-concept components, 2) Thinking components that consider the impact on others, and 3) Components of the motive that encourages development and others, and eleven variables. Thus, it is involved with the elements of weight at a reliable level, and it could be explained with statistical significance at the .01 level. In this case, the basic self-concept has the greatest weight of the elements with the results of student requirements to rely on their own knowledge. Thus, it is extensive and systematic and is integrated into creativity, so this is the starting point for innovation that is unique.

According to the summary of the development of a causal relationship model, there are two issues of creativity and innovation as follows: 1) the quality of the developed model, the cognitive component affecting other people and the driving force toward development, and the causal variable was analyzed by SEM to explain the variance of .768, which assumed that the test model could explain the causal relationship of creativity and good innovation, and 2) the findings that confirmed from the empirical data that all three factors influence the creativity and innovation in students with one element of basic self-concept in the composition to consider the impact on others at the .97 level. Therefore, the second component on the aspect of considering the impact on others will influence the motive element of development at the .73 level, and the third component order on the fundamental factors of self-concept will influence the composition for the driving factor that

stimulates development at the level of .12.

8. Discussion

In the concept of creativity, the aim is to create a thinking process that is different from conventional thinking, (Sternberg, 2003). Moreover, creativity relies on intrinsic cognitive skills integrated with extrinsic knowledge until becoming a multi-faceted idea for solving industrial product design problems. In this case, according to the concept of creative elements, it shows the rational thinking by relying on knowledge within oneself and outside oneself, (Iskandar and Juandi, 2022). Then, it is presented as a solution to problems that is different from the usual approaches. Moreover, the process of creativity must be practiced continuously under the conditions of the environment in which the students live until it becomes a novel innovation and meets human needs, (Wannapiroon and Pimdee, 2022; Egwutvongsa, 2023).

With regard to creativity, it is critical to innovation in the 21st century by instilling innovative skills in students. Moreover, it is important because it is the source that provides the origin of new innovations by relying on learning based on schema theory, and it helps to encourage the minds of learners with experience born from their own senses, memories and thoughts, (Egwutvongsa, 2022). In this case, when combined with Phenomenon Based Learning, students can practice and attempt to solve product design problems until gaining experience that arises from learning from real situations. Thus, it will help to build creative skills for learning within oneself and from the combination of knowledge that they have. Together with trial and error, it becomes a creative skill that is cultivated until becoming profound knowledge in creating new innovations in the future, (Gajdzik and Wolniak, 2022). Thus, it enables the combination of the concept of learning found in Schema Theory and Phenomenon Based Learning that have led to modeling, creativity and innovation to occur with students, which consists of three factors as follows:

1) Basic factors of self-concept consisting of Growth Mindset, Thinking, Art, Mathematics, Creativity, and Innovation, all of which are knowledge of various sciences. In addition, it helps to think systematically with critical thinking for preparing the students with attitudes and fundamental knowledge that help to strengthen knowledge and understanding by independently presenting solutions to product design problems, (Ceylan, 2022).

2) The factor of considering the impact on others consists of Physiology, Economics, Psychology and others, which is knowledge that reflects the impact that is likely to occur until affecting other people after solving industrial product design problems.

3) The factors of driving development consist of Social Sciences and Motive, which is the nature of the idea that ultimately occurs, and it is an important driving force for creating new innovations. Hence, according to the third factor, there will be a shift from abstract knowledge to concrete knowledge that will appear with the innovative results, (Magistretti et al., 2022; Lertchamchongkul and Egwutvongsa, 2022).

According to all three factors, it was shown that the eleven variables are similar to the concept of innovation for Design Thinking that integrates a variety of knowledge. Consequently, it occurs after presenting a solution to the problem and integrating the existing knowledge and skills to create real product prototypes, (Zhang, 2023).

Therefore, the creativity and innovations must be encouraged within the students' own drive to be developed or improved because it is derived from their minds, which will help to create perseverance. As a result, the students want to learn with the readiness to present new creative ideas within the situation so as to effectively meet the human needs of the 21st century, (De Vasconcelos Gomes et al., 2022; Israel-Fishelson and Hershkovitz, 2022; Al Awabdeh and Albashtawi, 2023).

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