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Original Paper

Curriculum Experience and Learning Outcomes for Creativity Competence: Empirical Survey of Undergraduates in the Engineering Domain

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Abstract

In the last decades, creativity has been advocated as a key learning process in the engineering domain to advance college students' abilities in technology and science. Creative education becomes a mantra which is enhanced by educators, politicians, employees, teachers, professors, and students. Creativity competency is viewed as a crucial solution to face the challenges of industrial promotion, human capital investments, and future societal strategies and overcome the social, economic, and educational problems. College students' competency on creativity represent a series of attributes, behaviors, knowledge, and abilities required for successful learning performance in the engineering domain. This paper discusses on the results of an empirical study on college students' competences in the engineering domain and their self-evaluation on their perception of creativity and creativity performance. Universities are strongly expected to provide learning opportunities that foster and nurture creativity for students, hence creative education in engineering is an ongoing critical mission for both educational institutes and learners. The research was conducted through a testing questionnaire by theoretical literature review and focus group interviews with experts in engineering and education fields. The samples are tested by the instrument and there were 307 valid samples for analysis. The statistical method includes means, x^2*, and the structural equation model. The curriculum experience is the strongest correlation value (r=.55) to affect creativity achievements. The learning styles have an obvious influence on school environments (r=.44), and school environments are shown the same value (r=.45) to curriculum experience. The self-evaluation by students demonstrates that school environmental improvement remains a key agenda for universities to be aware of in developing creative plans and managements for students. The engineering domain is specialized though its professions in the logics of learning along side of maker spirits, and this study* *leads us to have a clear observation among the various factors which influenced the educational plan or projects for college students. The conclusion provides suggestions for future empirical study and educational plans.*

Keywords

engineering education, creativity, undergraduate, competence

1. Introduction

Universities are increasingly expected to provide more opportunities that foster and nurture creativity for students; hence creativity education in engineering is an ongoing critical mission for universities. However, the importance of implementing creativity education in the learning experiences has not been fully recognized (Zhou, 2012). Studying on developing undergraduates with original and critical thinking, creativeness, and innovativeness, a fundamental theory is needed to meet the learning outcomes of engineering professions.

In the last decades, creativity has been advocated as a key learning process in the engineering domain to advance college students' abilities in technology and science. Creative education becomes a mantra which is enhanced by educators, politicians, employees, teachers, professors, and students. Creativity competency is viewed a crucial solution to face the challenges of industrial promotion, human capital investments, and future societal strategies and overcome the social, economic, and educational problems.

However, the traditional learning and teaching models are centered on the teacher and facilitate learning environments and achievements limited to the classroom. Traditional teaching and learning assignments to some extent hinders the cultivation of creativity for the youth in their professional attainments and technological implements. College students' competency on creativity represent a series of attributes, behaviors, knowledge, and abilities required for successful learning performance in the engineering domain.

Given that barriers exist in the engineer education for students, the case study of a university in this article mainly includes the colleges of Engineering, Electrical Engineering and Computer Science, and Design. The examined university has launched a pilot educational project "Creative Learning for Engineering Domains" that was funded by the Ministry of Technology and Science in Taiwan from 2015 to 2017. The "Creative Learning for Engineering Domains" project emphasizes the college students' competences of creativity learning and improvements in the engineering domain to fit into the uncertain and evolving circumstances in the high-tech society.

Comprehensive universities provide diverse learning opportunities to cultivate the creativity of engineering students, which is a critical educational goal in the era of knowledge and technological innovation. The learning process that promotes creativity education is affected by different factors. Among all, the path through curriculum experience can be regarded as a direct way of cultivation on creativity. In addition, the individual's internal learning style and the external school environments are worthy to investigate. According to the profound experiences on teaching and learning in the engineering-related domains, the empirical evidence-based data and results are worthy of further exploring. Therefore, the researchers conduct survey to explore the self-evaluation of the learning experience and creativity performance of engineering students.

2. Purposes

This research was conducted through a quantitative approach via a questionnaire and investigates students' self-evaluations of their awareness and opinions regarding the learning experiences of creativity attainments in the engineering and technology courses. The study applies a structural equation modeling approach to examine the students' creativity learning. The research aims to exploring the following issues:

A. Developing and implementing a survey instrument that corresponded to the theories of creativity competences.

B. Analyzing college students' creativity competences based on the dimensions of learning styles, school environments, curricula experiences, and achievements in the learning outcomes

C. Assessing the relationships of the impact factors and influential values among latent variables through Structural Equation Modeling (SEM)

D. Providing conclusions and suggestions to academic and practical prospects for engineering education in colleges and universities

3. Theoretical Reviews

Development of new ideas and original product is a particularly human characteristic. The associated theories and perspectives about creativity stem far back into history, and a systematic study of it began in the middle of the last century.

When Guildford (1950) theorized "the structure of intellectual model" to examine the creativity of talent students, he inquired into how we can discover creative potential in our children and our youth and how we can promote the development of creative personalities. These issues should be observed in a long-term viewpoint to enforce the young generations' achievements in their professional performance. The argument pointed towards a new way of thinking about personality to influence learning outcomes on creativity and creative productivity through education approaches.

Afterwards, Williams (1972) expanded the testing of creativity scopes from the cognitive dimension to affection dimension and produced the four core factors: curiosity, imagination, risk-taking, and challenge-solving. While referring to the aspects of personality, Torrance (1988) indicated that there are six psychological characteristics that affected individual achievements in creativity: courage, independence of thought and judgment, honesty, perseverance, curiosity and willingness to take risks. Other than the above referred elements, Csikszentmihalyi (1999) showed that a learner's mutuality in professions, recognition toward domains, and personal performance are all influential factors when advancing an individual's ability of creativity.

Going far beyond the previous stances, Amabile (1996) proposed an approach to illustrate the factors of creativity for individuals by providing a comprehensive picture of how the motivation for creative behavior and creativity itself can be influenced by the social environment. More recently, Amabile (2013) contributed the "componential theory of creativity" which is a model of integrating social and psychological dimensions for an individual to produce creative work. In these research findings, she indicated that the social context can influence motivation. On the contrary, motivation, in conjunction with personal skills and thinking styles, can lead to the expression of creative behavior within that context. Besides the aspects of college students' learning factors and influences, school environments are the most crucial sites for learners to gain creativity competences because it is a key agency to provide a learning environment that supports students and teachers to cultivate their abilities. The school environment establishes a site from formal to non-formal learning for students to be dedicated perception and perceive the value of creativity (White & Lorenz, 2016).

In other words, course experiences are crucial to students' performance in enhancing of creativity attainments. McDonough and McDonough (1987) surveyed how the colleges and universities in the United States implement formal courses for creativity. They found that the response from 961 of the 1,188 schools indicated that they did not offer any courses in creativity and some schools conducted creativity courses but were omitted from the survey. It appeared that only a small number of colleges and universities in the United States prospected courses of creativity about 2 decades ago. Curriculum experience is an exceptionally important part of college students' development in the professional program (Kliege & Sherman, 2015).

Curriculum and pedagogy of engineer domains can convey by quality project work to train the students' competences and further evaluates the students' course learning outcomes (Deepamala & Shobha, 2018). Yao (2020) evaluate students' competence on engineer course of equipping the profession on the temperature control theory and assess student's performance to attain goals of 'the design process was clearly and logically described. The use of equations, figures, and other visual aids was effective' and "The designed system provided steady-state error and overshoot temperature that are both within the safe egg hatching range. The system performance was thoroughly analyzed against the egg hatching requirements identified earlier." The achievements by profound learning experience are critical to in sure students' attainment on their professions. Situating teaching goals as embedded in curricular frameworks, teacher practice and student experience which is illustrated in reflections on the cultivation of engineering education. Students need to enact their role as professional engineers and teachers bring the tacit of creativity to the teaching and learning space which are necessary to overcome the lack of creativity in the engineering education (Sipson, Inglis, & Sandrock, 2020). In these decades, the learning issues of creativity have become prevalent in higher education, but it is unclear how to best develop them to provide systematic skills and knowledge for learners. In essence, the course experience should entail teaching and pedagogical structures with a more concentrated and student-centered approach to learn new patterns and prospects of creativity in the engineering domain.

Most researchers indicate the importance and influence of personal characteristics on creativity performance; on the contrary, Csikszentmihalyi (1999) showed that a learner's mutuality in professions, recognition toward domains, and personal performance are all influential factors when advancing an individual's ability of creativity. Since students take on different tasks while dealing with real engineer problems, it is necessary to develop multiple skills and to have mastery experiences for increasing students' self-confidence or self-efficacy. Students' engagement in classroom to achieve their learning outcomes also depend on the students' gender or class participation, which are composed as students' learning style (Hirshfield & Chachra, 2019). Sternberg (2012) with his colleagues comprehended the invest theory of creativity as a leaping-off point for designing the assessments of creativity. This assessment tool provided a basic structure on the grounds that the elements of cultivating students' creativity bear both verbal and nonverbal levels. It was limited in the domains chosen for analysis and the samples included ages ranging from elementary school through adulthood which didn't focus on the undergraduates in the engineering fields. This research focuses on higher education and applies factor analysis and structural equation modeling as its empirical and data-based exploratory approach.

To sum up, the students' learning of creativity competences are influenced by the students' personality of learning, school environment and designed curricula for students' improvements. Moreover, compared to previous analysis and theories, this study will focus on higher education and apply factor analysis and structural equation modeling. Some articles that explore related topics use college students as survey samples, but the results lacked students' worldviews or experiences (Kukushkin & Churlyaeva, 2012; Sawyer, 2015). In order to extend our understanding to the empirical facts of the learners in their cultivation of creativity competences, this article will highlight the engineering college students' standpoints. With respect to this, the study collected data of about college students' self-evaluation on their perspectives and opinions towards undergraduates' competency of interdisciplinary creativity in the Asian context.

4. Research Method

The above literature reviews provide a timely overview of the factors in creativity education and advance the components and structures of students learning on this subject. The researcher constructed a survey instrument according to the primary literature reviews and conducted focus group interviews to examine the questionnaire with experts who majored in the related fields. Deepamala and Shobha (2018) define score criteria for course of "Computer Science and Engineering" as listed of: engineering knowledge, problem analysis, design and development of solutions, conduct Investigations of complex problems, modern tool usage, the engineer and society, environment and sustainability, ethics, individual and team work, communication, project management and finance, and life-long learning. These components are basic reference for the development on research questionnaire.

The research dimensions covered four aspects and each aspect is composed in question format. The numbers of testing items are shown in Table 1. The aspects include learning styles (6 items), school environments (4 items), curriculum experiences (7 items) and creativity achievements (5 items).The parentheses are shown as the number of testing items.

Table 1. The Latent and Observed Variables for the Survey Instrument

Latent variables	Observed variables
Learning styles (6 items)	a1=developing day by day; a2=exploring new knowledge; a3=overcoming obstacles; a4=pursuing cooperation and opportunity; a5=inquiring complicated problems; a6=realizing things thoroughly
School environments (4 items)	b1=the institutes emphasize creativity; b2=teachers advocate creativity; b3=events or competitions for students; b4=freedom and openness of school environment
Curriculum experiences (7 items)	c1=cross-disciplinary; c2=creative thinking; c3=creative knowledge; c4=multiple perspectives; c5= exploring more possibility; c6=concretization ideas; c7=breaking limitations
Creativity achievements (5 items)	d1=sensitivity; d2=fluency; d3=flexibility; d4=originality; d5=elaboration

Owning to the research design of time, budget, and sample size, the survey was conducted in a department of Mechanical Engineering in the university which is famous on its engineering education in Taiwan. The quantitative research method of testing and survey are used to testify students' achievements, opinions, skills, and learning-outcomes on students' creativity achievements. The researcher established a questionnaire based on the literature review and launched a focus group interview with experts in the related fields for this study. The major and background of the experts are shown as follows:

Table 2. Experts for Focus Group Interview

expert	Major field	expert	Major field
A	Micro Acoustic Wave Sensor, RF Signal Processing Device, Micro-generation、Acoustic Touch Panel	D	Emotional Design, Human Factor, Product Design, Usability Engineering, Website Design
B	Human-Computer Interaction, Context-Aware Computing, Ubiquitous Computing	E	Electronic Ceamics and Glasses, Sol-Gel Process,
C	Material Characteristics, Communication Technology, Social Computing, Speech Recognition Multicast, Recognition based learning, Switching	F	Semantic Web, Web2.0, Engineering Electronization of business, Natural language processing, Artificial Intelligence

The respondents of this survey were student taking courses related to the engineering domain. The survey was conducted on the students who took the courses that aimed to improve the learners' creativity in the engineering domain. The control of measures was implemented by several principles as: being conscious of multiple roles, notifying participants of the goals of this survey, following informed-consent rules and respecting confidentiality and privacy. The students were allowed to stopatany stage when they intended to quit participating the survey.

The subjects of each course are shown in Table 3.

Table 3. Testing Sample of the Courses

Courses	N	%
Evaluation on the Ageing Wisdom and Creation	7	2.3
Electronic Ceramics	37	12.1
Mechanic Production	65	21.2
Maker Thinking	47	18.6
Creative Practice of the Software Service and design	53	17.3
Advanced Mechatronics Systems Engineering	7	2.3
Design on Electromechanics	41	13.4
Digital Maker	21	6.8
Total	307	100.0

The samples' backgrounds of sex and school years are shown as Table 4.

Table 4. Samples' Backgrounds

variable	N	%	variable	N%	
Sex			School years		
Male	247	80.5	1st	79	25.7
Female	52	16.9	2nd	12	3.9
Unanswered	8	2.6	3rd	111	36.2
			4th	88	28.7
			Above 5th	8	2.6
			Unanswered	9	2.9
Total	307	100.0%	Total	307	100.0

In total, there are 307 completed samples that filled out the questionnaire. In order to describe the characteristics of the students' background variables, the descriptive statistics of the samples are shown in Table 4.The Cronbach's value for the reliability of the instrument is .946 and validity value of the Kaiser-Meyer-Olkin (KMO) is .943. Both the reliability and validity of the questionnaire are good for analyzing.

The results of the students' opinions and perceptions on each item will be shown through the descriptive statistics. Moreover, the relationship among all latent variables on influential and effect vales will testify by the Structural Equation Modeling (SEM).

5. Descriptive and Inferential Statistical Results

The results on the survey of the descriptive statistics and the influential statistical methods of the structural equation model finds of college students' competences in creativity of engineering domains areas follows.

5.1 Means of Each Observed Variable

There are four aspects which present as latent variables in the questionnaire and the aspects are learning style, school environment, curriculum experience, and creativity achievement. The means of each observed variables are shown in Table 5. The aspects of learning style are all higher than 3.18.Among the aspects of school environments, the item of "open school environment" shows the lowest grades of 3.05. In general, the means of curricula experiences all shows higher than 3.39, and among the creativity outcomes criteria, the students evaluate that producing creative and unique ideas and solutions are the highest grades as 3.38. In substance, the students' self-evaluation and performance demonstrate that the students learned and attained creativity knowledge, ability, and affection in their learning processes for professional development.

Table 5. Descriptive Statistics (Means and Standard Deviations) of Each Variable

Latent variables	Observed variables	M	SD
Learning style	a1=developing day by day;	3.18	.628
	a2=exploring new knowledge;	3.31	.583
	a3=overcoming obstacles;	3.36	.558
	a4=pursuing cooperation and opportunity;	3.38	.605
	a5=inquiring complicated problems;	3.26	.635
	a6=realizing things thoroughly	3.19	.665
School environment	b1=the institutes emphasize creativity;	3.30	.733
	b2=teachers advocate creativity;	3.20	.773
	b3=events or competitions for students;	3.21	.733
	b4=freedom and openness of school environment	3.05	.858
Curriculum experience	c1=cross-disciplinary;	3.40	.628
	c2=creative thinking;	3.51	.602
	c3=creative knowledge;	3.47	.601
	c4=multiple perspectives;	3.45	.582
	c5= exploring more possibility;	3.39	.615
	c6=concretization ideas;	3.46	.624
	c7=breaking limitations	3.45	.552
Creativity achievement	d1=sensitivity;	3.32	.550
	d2=fluency;	3.33	.624
	d3=flexibility;	3.34	.600
	d4=originality;	3.38	.566
	d5=elaboration	3.33	.624

5.2 Estimation and Goodness-of-Fit Test of Structural Equation Model

5.2.1 Test of the Skew and Kurtosis and the Estimation Method

The LISREL identifies the pre-assumption parameter estimation method by maximum likelihood estimation. If the hypothesis violated the normality allocation, the generally weighted least square should be adopted (Yu, 2006). Kline (1998) mentioned that when the absolute vale of skew is less than 3.0 and the absolute value of kurtosis less than 10.0, the model can be viewed as univariate normal allocation. This study will examine the normality allocation before testing goodness-of-fit by statistical software of SPSS 12.0. In Table 6, the analysis of the skew and the kurtosis are all with normal allocation and it is good for further testifying.

It shows that all of the related coefficient reach to a significant level (p<.01) by exemplifying the 22observed variables in Table 6, and the table further illustrates the relationship among all variables. The analytical model suits the parameter coefficient estimation and goodness-of-fit test.

Table 6. Means, Standard Errors and the Co-Relationship Values of the Observed Variables

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	D4	D5
A1	1.00																					
A2	0.60	1.00																				
A3	0.60	0.62	1.00																			
A4	0.57	0.58	0.50	1.00																		
A5	0.58	0.59	0.54	0.66	1.00																	
A6	0.54	0.54	0.52	0.55	0.65	1.00																
B1	0.31	0.28	0.21	0.22	0.27	0.25	1.00															
B2	0.32	0.29	0.25	0.26	0.29	0.33	0.75	1.00														
B3	0.31	0.25	0.26	0.21	0.25	0.27	0.55	0.59	1.00													
B4	0.25	0.24	0.21	0.19	0.24	0.27	0.50	0.53	0.51	1.00												
C1	0.41	0.32	0.30	0.34	0.30	0.36	0.40	0.41	0.34	0.29	1.00											
C2	0.38	0.34	0.30	0.39	0.40	0.35	0.47	0.48	0.44	0.36	0.64	1.00										
C3	0.41	0.35	0.26	0.34	0.29	0.34	0.45	0.44	0.42	0.33	0.60	0.69	1.00									
C4	0.41	0.42	0.34	0.46	0.40	0.36	0.41	0.39	0.35	0.28	0.65	0.71	0.68	1.00								

C5	0.38	0.31	0.34	0.39	0.36	0.40	0.37	0.37	0.43	0.28	0.58	0.59	0.53	0.57	1.00							
C6	0.36	0.33	0.37	0.35	0.36	0.37	0.41	0.42	0.40	0.32	0.65	0.69	0.65	0.67	0.58	1.00						
C7	0.35	0.32	0.32	0.35	0.28	0.33	0.38	0.38	0.36	0.37	0.63	0.69	0.65	0.65	0.60	0.71	1.00					
D1	0.48	0.40	0.39	0.45	0.37	0.42	0.47	0.51	0.47	0.39	0.48	0.56	0.53	0.55	0.45	0.52	0.54	1.00				
D2	0.40	0.37	0.34	0.37	0.37	0.39	0.39	0.42	0.38	0.28	0.46	0.55	0.45	0.53	0.50	0.49	0.53	0.61	1.00			
D3	0.42	0.37	0.37	0.37	0.42	0.40	0.28	0.29	0.35	0.29	0.40	0.41	0.36	0.48	0.46	0.49	0.43	0.57	0.51	1.00		
D4	0.36	0.35	0.32	0.33	0.36	0.36	0.39	0.38	0.35	0.33	0.41	0.59	0.53	0.52	0.40	0.53	0.55	0.55	0.69	0.52	1.00	
D5	0.45	0.37	0.40	0.36	0.41	0.42	0.38	0.37	0.29	0.29	0.47	0.52	0.46	0.51	0.43	0.49	0.51	0.55	0.50	0.60	0.58	1.00
M	3.18	3.31	3.36	3.38	3.26	3.19	3.30	3.20	3.21	3.05	3.40	3.51	3.47	3.45	3.39	3.46	3.45	3.32	3.33	3.34	3.38	3.33
SD	.63	.58	.56	.61	.64	.67	.73	.77	.73	.86	.63	.60	.60	.58	.62	.62	.55	.55	.62	.60	.57	.62
skew	-.31	-.38	-.36	-.49	-.36	-.37	-.80	-.63	-.62	-.66	-.64	-.90	-.84	-.50	-.57	-.89	-.30	-.01	-.37	-.41	-.22	-.46
kurtosis	.14	.52	.65	-.14	-.29	-.21	.20	-.25	-.02	-.17	-.12	.33	.75	-.68	-.11	.62	-.96	-.67	-.66	-.10	-.78	-.19

Note. the definition of each variables: A1 developing day by day, A2 exploring new knowledge, A3 overcoming obstacles, A4 pursuing cooperation and opportunity, A5 inquiring complicated problems, A6 realizing things thoroughly, B1 the institutes emphasize creativity, B2 teachers advocate creativity, B3 events or competitions for students, B4 freedom and openness of school environment, C1 cross-disciplinary, C2 creative thinking, C3 creative knowledge, C4 multiple perspectives, C5exploring more possibility, C6 concretization ideas, C7 breaking limitations, D1 sensitivity, D2 fluency, D3 flexibility, D4 originality, D5 elaboration.

5.2.2 Estimation on Goodness-of-Fit for the Structural Equation Model

The estimation on the goodness-of-fit for the structural equation model can be evaluated by the tests of offending estimates, overall goodness-of-fit, and internal goodness-of-fit. The test results areas follows:

Offending estimation test It shows the findings of the parameter estimation of model without negative error variations and no overlarge standardize errors. The results corresponded to the principles of "no negative error variations of the theoretical model" and "the standardized errors small." Moreover the absolute value is not close to 1 for fitting the testing standard.

Overall goodness-of-fit test It includes the measures of absolute fit, the parsimonious fit measures, and the incremental fit measures. The test value is shown in Table 7.

Table 7. Significant Test and of All the Estimated Parameter and the Overall Standardized Estimated Value

parameter	Loading	SS	t value
λx11	.80	SS	14.58
λx21	.81	.76	14.59
λx31	.78	.76	13.48
λx41	.81	.72	14.48
λx51	.83	.76	15.56
λx61	.79	.80	14.01
λx12	.86	.74	-
λx22	.88	.84	16.18
λx32	.80	.87	12.46
λx42	.75	.70	10.89
λx13	.67	.63	-
λx23	.75	.77	15.53
λx33	.68	.85	14.31
λx43	.72	.80	14.98
λx53	.58	.83	12.48
λx63	.73	.71	14.99
λx73	.72	.83	14.78
λy11	.65	.82	-
λy21	.68	.78	13.58
λy31	.62	.77	12.03
λy41	.69	.70	18.60
λy51	.64	.78	12.75

5.2.3 Overall Goodness-of-Fit Test

Overall goodness-of-fit test Overall goodness-of-fit test includes the measures of absolute fit the parsimonious fit measures and the incremental fit measures. The test value of overall goodness-of-fit test shows as Table 8.

Over all goodness-of-fit test includes evaluations of the measures of absolute fit, the parsimonious fit measures and the incremental fit measures. The values of each estimated value are shown in Table 8.

The measure of absolute test shows that the analysis model of the GFI value is .90. The SRMR value is .039 less than .08, and the RMSEA is .047 less than .05. All the values show that the variation among various samples is stable with goodness-of-fit. The established model and the observed data are with goodness-of-fit.

The measure of parsimonious test of CN value is influenced by the sample size and its value is 205. The PGFI of .72 and RMSEA of .80 are all with goodness-of-fit. The incremental measure of the NFI, NNFI, and CFI values are .91, .96, and .96. The results show that the theoretical model and observed data is with goodness-of-fit to explain the empirical data.

Table 8. Overall Abstracts of the Goodness-of–Fit in the Model

Measured values	P values	Values of the test	Goodness-of-fit
Absolute measure			
χ^2	≧.05	0.00	Fit
SRMR value	≦.08	0.039	Fit
RMSEA value	≦.05	0.047	Fit
GFI value	≧.90	0.90	Fit
Parsimonious measure			
PGFI value	≧.50	0.72	Fit
PNFI value	≧.50	0.80	Fit
CN value	≧200	205.46	Fit
Incremental measure			
NFI value	≧.90	0.91	Fit
NNFI(TLI) value	≧.90	0.96	Fit
CFI value	≧.95	0.96	fit

5.2.4 Goodness-of-Fit for the Testified Model

The test of the testified model shows that the factor loading values are all higher than .05and correspond to the evaluation standards of significance in all factor loading values. The Average Variance Extracted (AVE) of the latent variables are in the following order: .64, .68, .69, and .66. Moreover, all the 22 observed variables of the component reliability are .89, .84, .93, and .87.They are all reached the evaluated standards with good reliability in the model.

Table 9. Abstract of the Testified Model

Latent variables	Observed variables	Standardized Coefficient	Factor loading	Average variance extracted	Component reliability
Learning styles	a1developing day by day	0.80	0.65	0.64	0.89
	a2exploring new knowledge	0.81	0.66		
	a3overcoming obstacles	0.78	0.60		
	a4pursuing cooperation and	0.81	0.65		
	a5inquiring complicated problems	0.83	0.69		
	a6realizing things thoroughly	0.79	0.62		
School environments	b1the institutes emphasize	0.86	0.74	0.68	0.84
	b2teachers advocate creativity	0.88	0.78		
	b3events or competitions for	0.80	0.64		
	b4freedom and openness of school environment	0.75	0.57		
curriculum experience	c1cross-disciplinary	0.82	0.67	0.69	0.93
	c2creative thinking	0.87	0.75		
	c3creative knowledge	0.83	0.68		
	c4multiple perspectives	0.85	0.72		
	c5exploring more possibility	0.76	0.58		
	c6concretization ideas	0.86	0.73		
	c7breaking limitations	0.85	0.72		
creativity achievements	d1sensitivity	0.81	0.65	0.66	0.87
	d2fluency	0.82	0.68		
	d3flexibility	0.79	0.62		
	d4originality	0.83	0.69		
	d5elaboration	0.80	0.64		

5.3 Inferential Statistical Results of Structural Equation Model

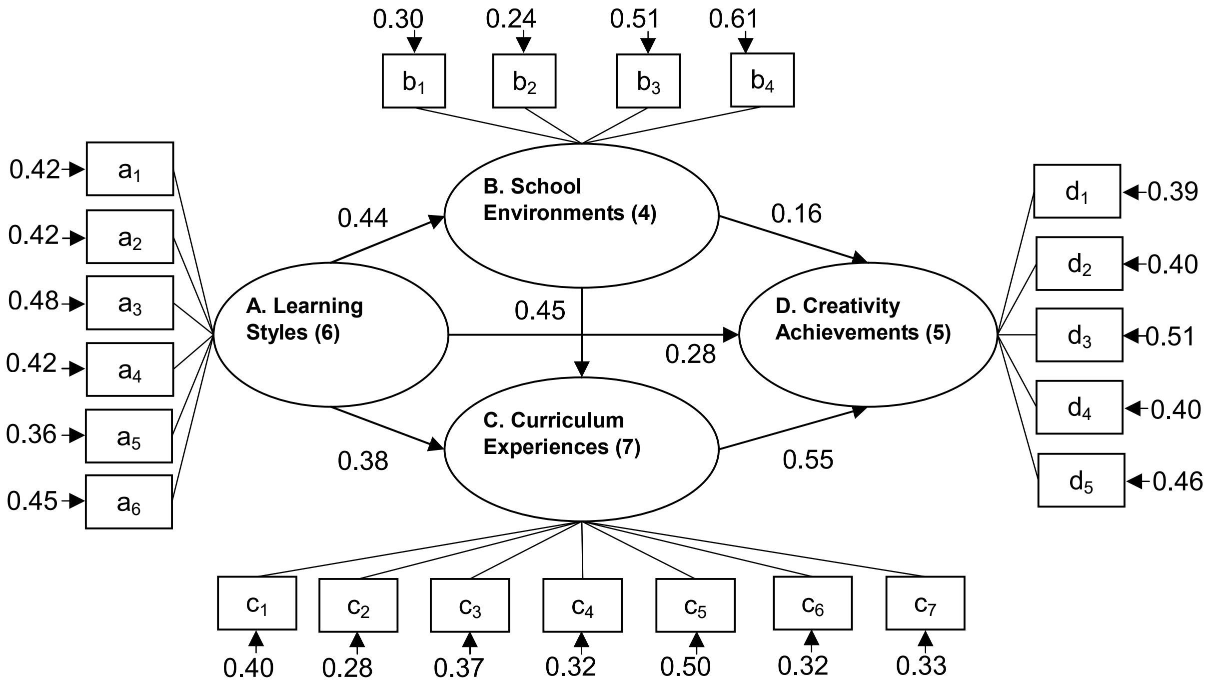
The structural equation modeling (Figure 1) illustrated that engineering students' performance and attainments in creativity are influenced by the personal learning style, school environments, and curriculum experiences in their creativity achievements.

It shows that in this model each aspect impacts the results of creativity achievements. Among all of them, the curriculum experience is the strongest correlation value (r=.55) to affect creativity achievements. The learning styles have an obvious influence on school environments (r=.44), and school environments are shown the same value (r=.45) to curriculum experience.

On the other hand, the school environments can directly impact on creativity achievements as the correlation value of r=.16, which is less strong in the model. Other results demonstrate that the correlation values of learning styles to curriculum experience arer.38 and that towards creativity achievements are r=.28. This model.

From the development of the interdisciplinary creativity questionnaire as well as the empirical survey, this article contributes to discourses and reflections related to the educational research and its practical progress. The research found the structural relationship among various dimensions and factors based on the data from an empirical survey, pointing out factor values and an influential route concerning the cultivating model of college students' competences on creativity for higher education in the engineering domain.

This structural equation model shows that college students in engineering domains learn and perform the creativity competence influenced by different factors. Overall, two strongest factors show influences on the students' creativity learning outcomes. The highest influential variable is students' learning style and the second one is students' experience within curriculum. The engineering domain students' accumulations and achievements of creative performance are obviously rooted in the solid curriculum plan and practices. The experimental results also enact and reveal the functions and missions for universities on cultivating creativity capacity for young generation.



χ^2=329.78, df=203, p<.000, RMSEA=0.047

Figure 1. The Structural Equation Model of the Creativity Achievements in the Engineering Domain

Note. Each factor in the model was indicated by four to seven indicators described as follows:

(1) a_1=developing day by day; a_2=exploring new knowledge; a_3=overcoming obstacles;a_4=pursuing cooperation and opportunity;a_5=inquiring complicated problems;a_6=realizing things thoroughly.

(2) b_1=the institutes emphasize creativity; b_2=teachers advocate creativity; b_3=events or competitions for students;b_4=freedom and openness of school environment.

(3) c_1=cross-disciplinary; c_2=creative thinking; c_3=creative knowledge;c_4=multiple perspectives;c_5=

exploring more possibility; c_6=concretization ideas; c_7=breaking limitations.

(4) d_1=sensitivity; d_2=fluency; d_3=flexibility;d_4=originality;d_5=elaboration.

6. Conclusions and Implications

6.1 Conclusions

This study explores engineering students' self-evaluation of their competences on creativity achievement which is influenced by personal learning styles, school environment, and curriculum experiences. Foremost, the author establishes a survey questionnaire to examine the performance and opinions of college students, and its reliability and validity illustrates that the instrument are good for testing the empirical circumstance.

The self-evaluation by students demonstrates that school environmental improvement remains a key agenda for universities to be aware of in developing creative plans and managements for students. There exists a significant influence in the relationship between the dimensions of personal learning styles, school environments, curriculum experiences, and learning outcomes on creativity competences. The conclusion of this model provides a positive stance for higher education to establish a whole-set structure on educating the youth with the ability of creativity.

The engineering domain is specialized though its professions in the logics of learning along side of maker spirits, and this study leads us to have a clear observation among the various factors which influenced the educational plan or projects for college students. These conclusions will further contribute to the philosophy and theory in advancing creativity competences of the learners.

The research established the survey instrumental questionnaire and the coefficient of Cronbach's α and KMO (Kaiser-Meyer-Olkin) showed results in a good measure level. All the coefficient of Cronbach's α of the latent variables are higher than .850 and the performance of each KMO value is above .835 with good value. This means that the questionnaire established by the researcher is with good reliability and validity for scientific implement in surveys.

Research findings shows that students are willing to learn from and cooperate with the other people or teams which enhance the capacity of creativity. To reach this goal, teachers have to lead students with more patience to understand new knowledge and motivate students to study and learn.

The students agree with the schools' efforts on cultivating their creativity, but indicate that the learning environments should be more free and open. This implies that a more adequate learning environment is necessary for creative development.

Teachers present good performance on advancing students' application of skills and methods in creativity, but are lacking in providing students' cross-disciplinary and cross-boundary thinking to progress in the future. As for the students' achievement in their learning outcomes on creativity, it is observed that most of the students can gain particular ideas and skills through the curriculum, but students still need helps on "constantly improvement on attitudes or methods" and "deliberately to discover or realize the things differences.” Overall speaking, students have good performance in some aspects and require promoting attitude and ability in specific competences.

6.2 Implications for Research and Practices

This study was conducted in a Taiwanese context with its own special cultural and educational tendencies, and it needs future testing in different fields and countries for a comparative study. The results of this paper derive from students’ self-evaluation in questionnaires, and it is also critical to collect information through in-depth interviews and focus group meetings to understand the individuals’ viewpoints and affections.

The practical movements in the higher education prevail to improve teaching and learning processes on creativity in the engineering domain and promote youth competence and competition in future industrials and countries. Tatung University has been promoting the creativity cultivation for students, and the “Creative Learning for Engineering Domains” project will be implemented for three years in total. In this study, the author suggests that the curriculum strongly impacts students’ performance in their creativity achievements. Therefore, the emphasis on creativity should correspond to the curriculum reform in the long term and the teachers’ ability to convey competences to students.

References

Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Amabile, T. M. (2013). Componential theory of creativity. In E. Kessler (Ed.), *Encyclopedia of management theory* (pp. 135-140). Thousand Oaks, CA: SAGE.

Csikszentmihalyi, M. (1999). In R. J. Sternberg (Ed.), *Implications of a systems perspective for the study of creativity*. Cambridge University Press, Cambridge. ttps://doi.org/10.1017/CBO9780511807916.018

Deepamala, N., & Shobha, G. (2018). Effective approach in making capstone project a holistic learning experience to students of undergraduate computer science engineering program. *JOTSE: Journal of Technology and Science Education*, *8*(4), 420-438. https://doi.org/10.3926/jotse.427

Guilford, J. P. (1950). *Creativity*, *American Psychologist*, *5*, 444-454. https://doi.org/10.1037/h0063487

Hirshfield, L. J., & Chachra, D. (2019). Comparing the Impact of Project Experiences across the Engineering Curriculum. *International Journal of Research in Education and Science*, *5*(2), 468-487.

Jahnke, I., Haertel, T., & Wildt, J. (2017). Teachers’ conceptions of student creativity in higher education. *Innovations in Education and Teaching International*, *54*(1), 87-95. https://doi.org/10.1080/14703297.2015.1088396

Klieger, A., & Sherman, G. (2015). Physics textbooks: do they promote or inhibit students’ creative thinking. *Physics Education*, *50*(3), 305-309. https://doi.org/10.1088/0031-9120/50/3/305

Kukushkin, S., & Churlyaeva, N. (2012). The Problem of Engineering Creativity in Russia: A Critical Review. *European Journal of Engineering Education*, *37*(5), 500-507. https://doi.org/10.1080/03043797.2012.718999

McDonough, P., & McDonough, B. (1987). A survey of American colleges and universities on the conducting of formal courses in creativity. *Journal of Creative Behavior*, *21*(4), 271-282. https://doi.org/10.1002/j.2162-6057.1987.tb00485.x

Sawyer, K. (2015). A Call to Action: The Challenges of Creative Teaching and Learning. *Teachers College Record*, *117*(10).

Simpson, Z., Inglis, H., & Sandrock, C. (2020). Reframing resources in engineering teaching and learning. *Africa Education Review*, *17*(3), 175-188. https://doi.org/10.1080/18146627.2019.1693899

Sternberg, R. J. (2003). *Wisdom, intelligence, and creativity synthesized*. Cambridge University Press. https://doi.org/10.1017/CBO9780511509612

Sternberg, R. J. (2012). The assessment of creativity: An investment-based approach. *Creativity research journal*, *24*(1), 3-12. https://doi.org/10.1080/10400419.2012.652925

Torrance, E. P. (1981). Empirical validation of criterion-referenced indicators of creative ability through a longitudinal study. *Creative Child and Adult Quarterly*, *6*, 136-140.

White, I., & Lorenzi, F. (2016). The Development of a Model of Creative Space and Its Potential for Transfer from Non-Formal to Formal Education. *International Review of Education*, *62*(6), 771-790. https://doi.org/10.1007/s11159-016-9603-4

Williams, F. E. (1972). *Encouraging creative potential*. New Jersey, NJ: Educational Technology Publications.

Yao, J. (2020). Temperature Control Project that Facilitates Learning of Difficult Concepts in Control Theory. *AEE Journal*, *8*(2). https://doi.org/10.18260/3-1-1115-36020

Zhou, C. (2012). Fostering creative engineers: A key to face the complexity of engineering practice. *European Journal of Engineering Education*, *37*(4), 343-353. https://doi.org/10.1080/03043797.2012.691872