ELSEVIER

7th International Conference on Computer Science and Computational Intelligence 2022

A SEM-neural network approach for understanding the entrepreneurial competence development of freshmen engineering and computing students

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Abstract

The discussion of enhancing entrepreneurial competence in Higher Education Institution (HEI), especially in engineering and computing major, has increased for the recent years. This study aims to propose and test a structural model of relationship of Indonesian HEI entrepreneurship education with entrepreneurship competence to assess student entrepreneurship competences especially in undergraduate level. Thus, this study provides the contribution in this stream by creating a subject specialized that fit with specific study program to enhance entrepreneurial competence for freshmen student called Integrative Survival Experience especially in engineering and computing major. We measure its output by using EntreComp questionnaires framework from European Commission. A combination of Structural Equation Modelling (SEM) and neural network was implemented as analytic approach in this study. The results show that the freshmen engineering and computing students develop entrepreneurial competence by enhancing the specific sets of ideas and opportunities as well as the capability to manage resources for taking the action afterwards. Apparently, the entrepreneurial competence development process of engineering and computing students differs with that of business and management students.

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1. Introduction

Entrepreneurship has become an important part of economic development in Indonesia where entrepreneurial practices have contributed to Indonesia's Gross Domestic Product (GDP) by 60% of Indonesia's total GDP in 2019, which represented by small and medium enterprise sector with ratio of entrepreneurship of 3.55%. Every University in Indonesia has at least one entrepreneurship subject or subject that related to entrepreneurship to accommodate delivery of entrepreneurship education. Delivery of entrepreneurship related subject in the faculty of engineering of President University is represented by a subject called Integrative Survival Experience (ISE). ISE subject aims to provide experiential learning for freshmen students by developing entrepreneurial competence that delivered by various modules that targets several competencies of three areas of ideas and opportunities, resources, and into action from EntreComp framework that developed by European Commission (EU), namely creativity, ethical & sustainable thinking, motivation and perseverance, mobilizing others, learning through experience, taking the initiative, and coping with uncertainty, ambiguity & risk. By considering that the students of ISE subject are freshmen students, the focus of the subject are on learning process, knowledge sharing & transfer, and gaining experience instead of hard measures such as number of new ventures created, and its survival rate.

Entrepreneurship Education nurture innovative talents that become an important driving force for future development in one country [1]. Currently, research on entrepreneurship education topic has covered several fields such as teaching staff in the system of entrepreneurial education [2], entrepreneurship-based curriculum development [3], and influence of entrepreneurship education to entrepreneurship intention [4]. Latest research discusses about entrepreneurial competences in higher education [5] with number of studies has discussed entrepreneurship competence with different context such as literature review on entrepreneurial competence [6], effect on entrepreneurial competence on business performance [7], necessary competence for entrepreneurial action [8], entrepreneurial competences in small and medium- size enterprises [9] and develop entrepreneurial competences to create new ventures in academic scene [10]. However, there is an underexplored relationship between entrepreneurship education with the development of student entrepreneurship competences. This article aims to propose and test a structural model of relationship of Indonesian Higher Education Institution (HEI) entrepreneurship education with entrepreneurship competence to assess student entrepreneurship competences especially in undergraduate level.

2. Literature Review and Research Model

2.1. Entrepreneurship Education

The entrepreneurial education defined as a whole education and training activity regardless inside or outside education system, which attempt to develop participants' entrepreneurial intention [11]. Most scholars (at 34%) argue that aim of entrepreneurial education is to create or increase entrepreneurial attitudes, spirit, and culture among individuals in general community [12]. The research also finds that entrepreneurial education is positively relatedto entrepreneurial attitudes and skills [13]. However, previous study has demonstrated that entrepreneurship education can improve entrepreneurial intentions through individual attitudes and cognition [14]. Linking the relationship between entrepreneurship education to Higher Education Institution, the previous study found that Colleges and universities have realized the value of entrepreneurship education and attempt to promote students' personal development through an entrepreneurship education program with its basic function to apply for a job and to become entrepreneurs that createnew jobs [15].

2.2. Tables Entrepreneurship Competences

Entrepreneurial competence defined as a specific group of competencies that related to the exercise of successful entrepreneurship and suggest that entrepreneurial competence as an underlying characteristic both generic and specific knowledge, motive, traits, self-images, social roles, and skills which lead to venture creation as well as surviving new venture and/or managing new venture growth [16]. Entrepreneurial competencies also defined as a higher-level characteristic which encompass personality traits, skills and knowledge and perceived as the total ability of the entrepreneur in get the job done successfully [17].

Entrepreneurial competence also discussed in the policy studies and resulted the EntreComp Framework [18]. This framework consider entrepreneurship as a competence that can be applied to all aspects of life starting from developing personal development, participate actively in social activity, enter or reentering job market, and to start a new venture. The framework has 3 dimensions namely ideas and opportunities, resources and into action. From three dimensions there are 15 competencies that can be measured as entrepreneurship competencies. Furthermore, this research has selected 7 out of 15 competences from EntreComp Framework [18] to work with, which directly reflect through ISE delivery, namely creativity, ethical and sustainable thinking, motivation, and perseverance, mobilizing others, learning through experience, taking initiative, and cope with uncertainty, ambiguity and risk as operational variables of the research. Creativity defined as a unique human trait that associated with adaptive capability to changing circumstances and effective cognitive capabilities to improve upon ideas that exposed or introduced [19]. From entrepreneurship pointof view, entrepreneurial creativity is a social and cognitive processes where entrepreneurs develop novel and problem-solving ideas which capable to create new market [20]. From EntreComp framework, creativity explained as an ability to develop several ideas and opportunities including better solution to existing or new challenges by exploring and experimenting with innovative approach which combining knowledge and resources in attempt of value creation [18].

Ethical and sustainable thinking defined as an ability to assess the consequences of ideas as well as the effect of entrepreneurial action to the market and environment by reflecting how sustainable the ideas which lead to act responsibly [18]. Motivation and perseverance defined as a determination in turning ideas into action in achieving desired goals both individual and group by being resilient when under pressure, adversity and facing temporary failure [18]. Mobilizing others is the ability to obtain and manage resources and make the most of limited resources available on hand through partnership, networking, and outsourcing [18].

Learning through experience is an ability to use any initiative in developing value as a learning opportunity with others such as peers and mentors to reflect and learn from the success and failure experience [18]. Therefore, defining learning through experience as experiential learning that is created through the transformation brough by the experience [20]. Experiential learning also encourages students in their activities to think more, explore, raise questions, make decisions, and to apply what they have learned [21]. Taking initiative defined as to initiate processes that create value by taking up challenges to act and work independently to achieve desired goals [18]. Lastly, cope with uncertainty, ambiguity, and risk defined as the ability to make decisions and act promptly, and flexibly in value creation process with limited information in a way of partial and ambiguous by testing the ideas and prototyping to reduce the risk of failing [18].

2.3. Hypothesis Development

There are six hypotheses were built from the seven competencies of EntreComp Framework encompassing seven competencies as operational variables namely creativity, ethical and sustainable thinking, motivation, and perseverance, mobilizing others, learning through experience, taking initiative, and cope with uncertainty, ambiguity, and risk. According to previous research on creativity and experience, it is found that learning through task experience (director indirect) provide more enhancements to the creativity compared to no task experience learning. Furthermore, it is also found that direct experience is more beneficial compared to indirect experience task in terms of team creativity [21]. Based on the explanation of previous concept, this study formulated into hypothesis 1 as follows: H_1 Creativity has positive association with learning through experience. Thus, the null hypothesis is creativity has no positive association with learning through experience.

Current research discusses experiential learning and ethics, responsibility and sustainability reveal that in order to integrate ethical and sustainable thinking into curriculum, experiential learning found to be an effective way to address those topics [22]. Hence, this study tries to propose hypothesis 2 as follows: H_2 Ethical and sustainable thinking has positive association with learning through experience. Therefore, the null hypothesis is ethical and sustainable thinking has no positive association with learning through experience.

Entrepreneurship education research that emphasizes on educational escape rooms as one of the forms of experiential learning found that student motivation in STEM subjects positively influenced by experiential learning inform of educational escape rooms [23]. Thus, the previous concept explanation can be formulated into hypothesis 3 as follows: H_3 Motivation and perseverance has positive association with learning through experience. So, the null hypothesis is motivation and perseverance have no positive association with learning through experience.

Based on the research about entrepreneurial competencies that utilized EntreComp framework, it is found that the ability to mobilize others in forms of mobilizing teams and environment influenced by student professional experience, which can be obtained by learning through experience or given task experience such as project-based learning [24]. Therefore, the concept explanation can be formulated into hypothesis 4 as follows: H_4 Mobilizing others has positive association with learning through experience. Thus, the null hypothesis is mobilizing others has no positive association with learning through experience. A study that conducted to hospitality students that engaged with experiential learning found that experiential learning has an impact increasing ability to take the initiative together with increased understanding of how organization works, career expectation, adapt to change, leadership skills, and financial management skills [25]. Hence, the concept explanation can be formulated into hypothesis 5 as follows: H_5 Learning through experience has positive association with taking initiative. So, the null hypothesis is learning through experience has no positive association with taking initiative. Research on students entrepreneurial learning through experiential learning stated that it enhances several learning outcomes which enhance problem solving ability under uncertainty and ambiguity. Based on the explanation can be formulated into hypothesis 6 as follows: H_6 Learning through experience others has positive association with cope with uncertainty, ambiguity, and risk. Thus, the null hypothesis is learning through experience others has no positive association with cope with uncertainty, ambiguity, and risk.

3. Methodology

3.1. Data Collection Methods and Sampling Design

This study employed survey method for data collection. The data was collected from engineering and computing students who were learning about entrepreneurship education in higher education institution. All the respondents that are targeted were approached by using purposive sampling with criteria. Thus, the similar standard was applied for all the sample. The first-year students in the university were selected as a respondent because they join with Integrative Survival Experience (ISE) subject. In this study, 4 items were used to measure spotting opportunities, 5 items were used to measure creativity, 3 items were used to measure vision, 2 items were used to measure valuing ideas, and 4 items were used to measure ethical and sustainable thinking. Those sub- variables are representing ideas and opportunities.   Resources will be represented by 4 items to measure self-awareness and self-efficacy, 5 items to measure motivation and perseverance, 4 items to measure mobilizing resources, 4 items to measure financial and economic literacy, and 4 items to measure mobilizing others. Whereas for representing into action, 4 items were used to measure taking the initiatives, 6 items were used to measure planning and management, 3 items were used to measure coping with uncertainty, 6 items were used to measure working with others, and 3 items were used to measure learning through experience.

The primary data were collected through online form (google form) and structured questionnaire was applied as a collection method in this study. It was collected in the lasted two months from September 2021 until the second week of October 2021. As a result, 293 respondents were collected from online form. To meet with the statistical requirement of applying structural equation modelling, this study adopting the range number of samplings with more than 200 respondents.

3.2. Data Analysis Techniques

3.2.1. Demographic Profile Respondents

A total of 293 respondents from first-year student at university participated in this study. All the respondents are engineering and computing student who were learning entrepreneurship education through Integrative Survival Experience subject as a respondent criterion. Most of the students were from Engineering Computing Faculty 163 respondents (55.63%), whereas Business Faculty were 130 respondents (44.37%). Overall, 59 respondents (20.14%) of the survey were Industrial Engineering Students, whereas Mechanical Engineering were 29 respondents (9.9%), Civil Engineering were 8 respondents (2.73%), Environmental Engineering were 19 respondents (6.48%), Information Technology were 48 respondents (16.38%), Business Administration were 61 respondents (20.82%), and Management were 69 respondents (23.55%).

3.2.2. Data Analysis

The two-step approach was applied in this study, including the test for the measurement model through Confirmatory Factor Analysis (CFA) and structural model for the hypothesis testing. To measure how the measurement items fit with the latent variables, this study adopting the goodness-of-fit criteria based on Henseler et al. [26]. Those criteria such as SRMR below 1 and NFI close to 1. As part of construct validity, this study put the criteria for loading factors which is more than 0.6. Meanwhile, the convergence validity criteria in this study should be fulfilled with an averaged variance extracted above 0.5. The last, the criteria of discriminant validity should be meet with a composite reliability (CR) score more than 0.7 and the square roots of the AVE scores should be bigger than the inter-construct correlations. A combination of Structural Equation Modelling (SEM) and neural network was implemented as analytic approach in this study. Hypotheses, reliability, and validity of the measures were verified by SEM, and on the other hand predictors of Entrepreneurial Competency development was verified by the neural network. When making decision, the complexity of relationship of variables was frequently over-simplified by SEM approach. Therefore, the research model includes neural network approach to assess the non-linear relationships. By design, the neural network is meant to learn linear and non-linear relationship that naturally complex between the entrepreneurial competency development factors and the decisions to determine which factors significantly influence the entrepreneurial competency development.

Furthermore, in comparison to traditional regression model the neural network prediction is more accurate. The ability to learn the data input in neural network offer the possibility to increase the accuracy, and therefore it allows the neural network to generalize situations that was not taught previously and make it a good tool for prediction. However, neural network is not suitable to test and examine the causal relationship of hypotheses because normally the neural network is not transparent, so it is difficult to understand how the network process relationship and comes to a certain prediction [27]. Considering the limitation of neural network, the overall research model and hypotheses were tested using SEM and the significant variables will be used as input to develop the neural network in order to for predict the significant factors that influence Entrepreneurial Competency development. This approach will have a better prediction of Entrepreneurial Competency development model rather than the traditional regression techniques.

4. Results

4.1. Inferential Data Analysis & Structural Model

In order to fulfil the measurement of model criteria, of the constructs have been tested. All the CR scores are more than 0.70. The score of all loading factor is more than 0.6 and it indicates as a discriminant validity. The square roots of AVE of the associated constructs are above the latent variable correlation between each construct. The AVE scores are above the 0.5 threshold point and it indicates the convergent validity. The structural model of the entrepreneurial competence development of engineering student depicted in Fig. 1 shows that creativity ($\beta = 0.318$, p-value = 0.162), and motivation and perseverance ($\beta = 0.035$, p-value = 0.697) has a negative association to learning through experience. Therefore, it is not support H_1 and H_3. Learning through experience is determined by the positive association of ethical and sustainable thinking ($\beta = 0.200$, p-value = 0.040) and mobilizing others ($\beta = 0.326$, p-value = 0.003). Thus, it supports hypothesis H_2 and H_4.

Taking initiative is determined by the positive association of learning through experience ($\beta = 0.540$, p-value = 0.000). These results support hypothesis H_5. Learning through experience ($\beta = 0.578$, p-value = 0.000) has positive association to cope with uncertainty, ambiguity, and risk and its support hypothesis H_6. The summary of the hypothesis of the entrepreneurial competence development of engineering student model shows in Table 1.

Compare to the structural model of the entrepreneurial competence development of business student exhibited in Fig. 2 shows that ethical and sustainable thinking ($\beta = 0.109$, p-value = 0.161), and motivation and perseverance ($\beta = 0.094$, p-value = 0.240) has a negative association to learning through experience. Therefore, it is not support H_2 and H_3. Learning through experience is determined by the positive association of creativity ($\beta = 0.174$, p-value = 0.040) and mobilizing others ($\beta = 0.448$, p-value = 0.000). Thus, it supports hypothesis H_1 and H_4. Taking initiative is determined by the positive association of learning through experience ($\beta = 0.595$, p-value = 0.000). These results support hypothesis H_5. Learning through experience ($\beta = 0.403$, p-value = 0.000) has positive association to cope with

uncertainty, ambiguity, and risk and its support hypothesis H_6. The summary of the hypothesis of the entrepreneurial competence development of business student model shows in Table 1.
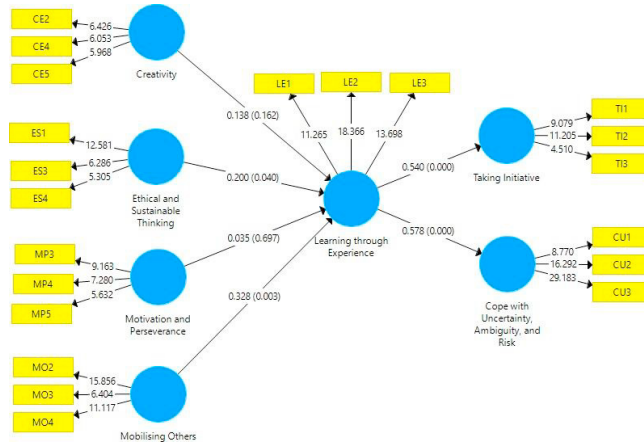

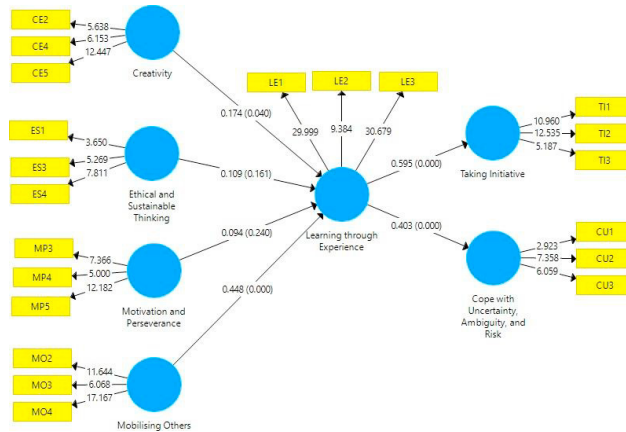Fig. 1 (a) Entrepreneurial competence development of engineering and computing student;

Fig 1 (b) Entrepreneurial competence development of bussiness student

Table 1. Hypothesis Summary

Hypothesis	Engineering Computing Student			Business Student		
	Original sample (O)	P values	Conclusion	Original sample (O)	P values	Conclusion
H_1: Creativity has positive association with learning through experience	0.318	0.162	Reject H_1 & Not reject H_0	0.174	0.040	Accept H_1 & Reject H_0
H_2: Ethical and sustainable thinking has positive association with learning through experience	0.200	0.040	Accept H_2 & Reject H_0	0.109	0.161	Reject H_2 & Not reject H_0
H_3: Motivation and perseverance has positive association with learning through experience	0.035	0.697	Reject H_3 & Not reject H_0	0.094	0.240	Reject H_3 & Not reject H_0
H_4: Mobilizing others has positive association with learning through experience	0.326	0.003	Accept H_4 & Reject H_0	0.448	0.000	Accept H_4 & Reject H_0
H_5: Learning through experience others has positive association with taking initiative	0.540	0.000	Accept H_5 & Reject H_0	0.595	0.000	Accept H_5 & Reject H_0

H_6: Learning through experience others has positive association with cope with uncertainty, ambiguity, and risk	0.578	0.000	Accept H_6 & Reject H_0	0.403	0.000	Accept H_6 & Reject H_0

4.2. Neural Network analysis for predicting Entrepreneurial Competency Development

In this study, neural network uses input from SEM, as it takes significant independent variables from SEM analysis to develop the neural network analysis. In this analysis, the number of samples of Engineering and Computing students are 122, whereas 110 samples for training (90.9%), 11 samples for testing (9.1%), and 1 sample was excluded. The input layer consists of four factors, i.e., creativity (CE), ethical and sustainable thinking (ES), motivation and perseverance (MP), and mobilizing others (MO). The total unit of input layer is 61. There is one hidden layer with only one unit in the layer. The activation function in the hidden layer uses the hyperbolic tangent. The output layer consists of one dependent variable consisting of 14 units, namely learning through experience, and the activation function used in the output layer is identity. The cross validation was performed in ten folds, whereby the neural network was trained by utilizing 90.9% of the data and the remaining 9.1% was used to measure the accuracy of the trained network accuracy. The sensitivity analysis performance is exhibited in Table 2. The average importance of the input variables is used to calculate the sensitivity analysis performance in predicting the networks output. There are two measures of sensitivity analysis performance: the importance and the normalized importance. The independent variable importance is a measure of how much the prediction of different value change of independent variables in the network's model. Whereas the normalized importance values were calculated by dividing the importance values by the largestimportance values. Table 2 shows that, variables related to MO and CE have the largest effect the prediction of Entrepreneurial Competency developments when compared to the ES and MP variables. As shown in Table 2, all the independent variables were relevant in the four networks.

Table 2. Independent Variable Importance

	Importance	Normalized Importance
Creativity (CE)	.246	72.2%
Ethical and Sustainable Thinking (ES)	.219	64.3%
Motivation and Perseverance (MP)	.194	57.0%
Mobilizing Others (MO)	.341	100.0%

5. Discussions

Based on the statistical result of SEM analysis, in the case of engineering and computing students, entrepreneurial competencies that influencing each other are ethical and sustainable thinking, learning through experience, taking initiative, and cope with uncertainty, ambiguity and risk. As a comparison, results in business administration and management study program students, creativity, mobilizing others, learning through experience, and cope with uncertainty, ambiguity and risk found to influence each other. The difference located in creativity where it does not support positive association with learning through experience in engineering and computing students but supported in business administration and management students. Secondly, in the ethical andsustainable thinking competence for engineering students is supported to have positive association with learning through experience but it is not supported for business administration and management students. Compared to the previous study, the result of this study has higher possibility to increase the accuracy and better prediction since it supported by the neural network prediction. Thus, the result could contribute to the enhancement of the student entrepreneurial competence from engineering and computing study program with specific focus.

6. Conclusion

In conclusion, positive association of learning through experience to taking initiative and learning through experience to cope with uncertainty, ambiguity and risk in both samples are influenced by Learning through experience which in line with previous research. The difference in the variables that influence learning through experience indicate that learning through experience through experiential learning is important aspects in the delivery of ISE subject. Authors recommend the type of experiential learning for engineering students to aim ethical and sustainable thinking and mobilizing others. While for business and management students to aim more to the creativity in terms of learning through experience. Furthermore, the neural network model result in predicting Entrepreneurial Competence development of Engineering and Computing students shows that the four significant variables resulted from SEM approach are all relevant in predicting the Learning through Experience factor. The neural network model also shows that Mobilizing Others (MO) and Creativity (CE) variables played larger roles in predicting the Entrepreneurial Competencedevelopment. Therefore, the importance of Integrated Survival Experience subject in development of entrepreneurialcompetence of Engineering and Computing students was confirmed. It is suggested that the subject is recommended to be given to non-business students.

Acknowledgement

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