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A Decision Making and Clustering Method Integration based on the Theory of Planned Behavior for Student Entrepreneurial Potential Mapping in Indonesia

Nova Rijati[1,2]* Diana Purwitasari[1] Surya Sumpeno[1] Mauridhi Hery Purnomo[1]

[1]*Department of Electrical Engineering, Faculty of Intelligent Electrical and Informatics Technology, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia*
[2] *Department of Informatics, Faculty of Computer Science, Universitas Dian Nuswantoro, Semarang, Indonesia*
* Corresponding author's Email: nova.rijati@dsn.dinus.ac.id

Abstract: One of the Indonesia Government strategies in the human resources field is preparing peoples such that they can create new jobs. In the higher education level, all universities in Indonesia are encouraged to be able to produce young entrepreneurs from among students. However, not all of the students have the same entrepreneurial potential. The university management needs to map the students to be prepared as the prospective entrepreneurs. This study is proposed to reveal the hidden knowledge of student entrepreneurial potential mapping from the higher education database. The integration of the decision making model and clustering method based on the theory of planned behavior is utilized to achieve this objective. The fuzzy multi-attribute method is applied in the decision making approach. Whereas, the k-means clustering is selected to generate the group of student entrepreneurial potency as the entrepreneurial potential mapping. Experimental results show that there are four identified clusters to present the student entrepreneurial potential levels. The first cluster consists of the students who have medium and high potential levels of 68% and 32%, respectively. The second cluster consists of the students who have medium, high and very high potential levels of 19%, 69%, and 12%, respectively. The third cluster consists of the students who have high and very high potential levels of 50% and 50%, respectively. While the fourth cluster consists of the students who have medium and high potential levels of 18% and 82%, respectively.

Keywords: Student entrepreneurial intention, Student entrepreneurial potential, Entrepreneurial behavior, Theory of planned behavior, Fuzzy multi-attribute decision making.

1. Introduction

Entrepreneurship is a process of applying creativity and innovation in solving issues and seeking opportunities to make a better living [1]. Entrepreneurship does not an instant process and it relates a behavior that requires being planned. Based on the theory of planned behavior (TPB) [2], entrepreneurial activity is preceded by entrepreneurship intention that is influenced by three beliefs: attitude, subjective norm, and perceived behavioral control. These beliefs could lead someone into a successful entrepreneur. In the student entrepreneurship context, the contribution of attitudes belief on entrepreneurial activities could be autonomy and authority, economic opportunity and challenge, security and workload, self-realization and participation, and need for achievement [3-4]. The subjective norm belief could be interpreted as academic support because universities must provide entrepreneurship skills toward its scholars and encourage them to take entrepreneurs as their career [5]. The perceived behavioral control is usually an external factor such as resources and opportunities that align the intention and behavior [6, 7].

In Indonesia, student entrepreneurial potential development is one of the national strategic programs to increase the national economy standard [8]. This strategy is also designed to anticipate the era of demographic bonuses, where the population of productive age is larger than the non-productive age. This condition is predicted to reach a peak in 2028 to 2031 based on the Central Bureau of Statistics reports. In 1998, the Indonesian

Government introduced the student entrepreneurship creativity program (SECP) to accelerate the growth of student entrepreneurs. Further, entrepreneurship was publically declared as a compulsory subject to all universities in Indonesia since 2012.

Each university in Indonesia should provide adequate facilities and environments to encourage the abilities and skill of student entrepreneurship. A student entrepreneurial potential mapping should be designed for decision making to implement the continuous entrepreneurship program based on the potential of respective students. Unfortunately, there is no definitive model that can be adapted to present the student entrepreneurial potential mapping for those purposes above. Referring to the current state, the Indonesian higher education database just mainly focuses on transactional data of education, research, and community service. There is no related data of the national student entrepreneurship that can be used for decision making in the entrepreneurship program directly. However, the Indonesian higher education database contains many attributes of students and feasible to be considered to construct the TPB model of the student entrepreneurial potential mapping.

Recognizing the student entrepreneurial potential through the TPB does not ease practically. Most researchers utilized questionnaire-based data to elaborate and map the student entrepreneurial potential. However, there are many disadvantages in the use of the questionnaire to collect the behavioral characteristics of students. Students perhaps in a hurry to fill out or answer questionnaires, unable to answer difficult questions, give answers that are not forthright and give answers that are not under the actual situation even though they fill out a blind or closed questionnaire with anonymous. All of these cases will produce a questionnaire with low validity so that difficult to gain a valid conclusion. Besides, questionnaire-based student entrepreneurial data analyses are usually applied in the limited or regional area and difficult to generalize into the national scale policies.

The TPB approach has been widely used for the entrepreneurship model analysis. However, there are only a few studies deal with the entrepreneurial clustering method based on the multi-attribute decision making model. The $k-$means clustering on a dataset consisting of a simple multi-attribute rating technique (SMART) ranked, which are varied value and weight attribute to generates simplified attribute [8]. The integration of the fuzzy analytic hierarchy process (AHP) technique with k-means clustering to segment customers into dominant characteristics-based clusters [9]. The multiple-criteria decision making (MCDM) technique cluster evaluation on the analysis dataset, which increases the effectiveness of evaluation processing and generates better clusters [6, 10]. The information preference-based multi-criteria technique to generate a better cluster by combining the previous cluster with the clustering assembly technique [11]. The generating optimum cluster with dynamic multi-objective decision technique [12]. The MCDM optimization, which integrates simple additive weighting (SAW), a technique for order preference by similarity to ideal solution (TOPSIS), and Borda technique [13]. This technique is the most profitable decision on selecting tools to minimize production resources. Meanwhile, a combination of SAW, TOPSIS, and grey relational analysis (GRA) techniques could produce the best decision by minimizing the influence on assessing weight preference [14]. The other researcher measured entrepreneurship interest based on the TPB using fuzzy logic with five levels of entrepreneurship interest [15].

This study is proposed to develop a student entrepreneurship potential mapping for the decision making model by integrating the fuzzy multi-attribute decision making (FMADM) and clustering techniques. It is expected to support decision making by determining the entrepreneurial potential level and map-based clustering method. The mapping for the student's entrepreneurial potential would then be displayed by applying the TPB's variables on the higher education database referring to the national standard's higher education. There is a strategic process to apply the knowledge discovery on the higher education database to generate the student entrepreneurial potential map. Meanwhile, the result of this research may help the university management to evaluate and compile an appropriate policy on generating the student entrepreneurial intention in the sense that the student entrepreneurial potential. However, the higher education database is sometimes not ready to use for decision making. An incomplete, vague, or inconsistent variable causes a fuzziness in the dataset [7, 18, 19]. To address this issue, the FMADM method is applied in this study.

Based on data type, FMADM could be divided into 3 types, which are fuzzy data, crisp data, and the combination of fuzzy and crisp data [33]. There are many methods in FMADM, such as SAW, weighted product (WP), elimination et Choix traduisant la realite (ELECTRE), TOPSIS, and AHP [7, 8, 18]. Some FMADM techniques also mixture one or more methods, such as SAW with TOPSIS [13], SAW with WP [22], and TOPSIS with a fuzzy cognitive map (FCM) [34]. The mixture of SAW

and TOPSIS shows the most efficient method to determine the most appropriate decision alternative in the case of multi-attribute decision making [13, 14, 20-22]. Hence, this study will use the integration of the SAW and TOPSIS to address the fuzziness of the student entrepreneurial potential rank.

Technically, the FMADM is used to pick out the TPB variables that influence the student entrepreneurial intention. The intention may consist of a varied value and weight of attributes, which are formulated as alternatives solutions for assessing student entrepreneurship. In this case, the fuzzy logic is used to define a qualitative, inaccurate and vague variable such as an attitude variable. Overall, the use of the FMADM technique is to determine the decision on several incomplete, vague, or inconsistent variables-based alternatives [7]. This study also uses a clustering technique to generate student entrepreneurial clusters as student entrepreneurial potential mapping. The students in one cluster could have a very high characteristic similarity in the same cluster, but dissimilar the other students in a different cluster.

This paper is organized into several sections, as follows. Section 2 presents the fundamental of the theory of planned behavior. Section 3 presents the methodology of this study, including the dataset and the proposed method. The main proposed steps are defining the student entrepreneurial potential attributes, defining the student entrepreneurial potential rank, and creating the student entrepreneurial potential map. The experimental results and discussion of this study are presented in Section 4. Finally, the conclusions and future works of this study are summarized in Section 5.

2. Theory of planned behavior (TPB)

The TPB was originally introduced from the theory of reasoned action, which is proposed to predict the intention of individuals to involve in a behavior. The essence of TPB explained that each individual has a behavioral intention as the main self-control abilities in behaviors. This means that behavior achievement will be determined by both intention and behavioral control. The behavioral intention represents the strength of the individual willingness to perform a certain behavior. In TPB, the actual behavior can be influenced by behavioral intention, which is constructed by the three kinds of beliefs that are attitude, subjective norm, and perceived behavioral control [17, 38]. Fig. 1 shows the construction of TPB that is built from these three interrelated beliefs.

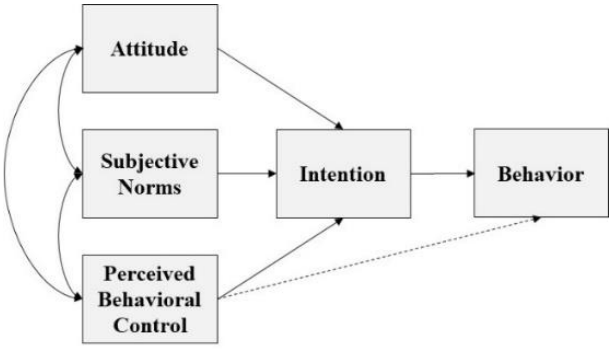

Figure. 1 Theory of planned behavior construction [17]

Attitude, the first major belief to determine the behavior intention, refers to the degree to which individuals in response to the favorable or unfavorable risks in the behavior.

The attitudes belief can be either a positive or negative assessment of something given in the environment. The attitude belief links to a certain outcome in behavior, or some attributes associated with this belief. To estimate this attitude outcome, one or more evaluation attributes can be used as the expectancy-value model [17], as formulated in Eq. (1).

$$A_B \propto \sum_{i=1}^{k} b_i e_i \tag{1}$$

where A_B is an attitude toward behavior B; b_i is a behavior belief that performing the behavior B with outcome i; and e_i is an evaluation of outcome i.

The subjective norms refer to the external factors that influence individuals to do or not do a behavior. This normative belief can be in the form of pressure that comes from peers, society, institutions, or the other external environments. The relation between the subjective norm and normative beliefs is formulated in Eq. (2).

$$SN \propto \sum_{i=1}^{k} n_i m_i \tag{2}$$

where SN is the subjective norm, n_i is the normative belief with referent i, and m_i is the motivation with referent i.

The third belief is the perceived behavioral control, which is an individual perception that affects the ease and difficulty to perform the behavior. This belief can be either resources or support that increase the strength of intention, but on the contrary, it can be either an obstacle or weakness that can decrease the individual intention to perform the behavior. The relation between the control

beliefs and the perceived behavioral control is formulated in Eq. (3).

$$PBC \propto \sum_{i=1}^{k} c_i p_i \quad (3)$$

where PBC is the perceived behavioral control, c_i is the control belief with factor i, and p_i is the power of factor i to facilitate the behavior. These three beliefs above have a different level of contribution and impact on behavior intention respectively. The individual situation and condition will play a significant role in determining the degree of behavioral intention.

The TPB has been widely applied in various research fields, such as health service utilization, smoking, breastfeeding, drinking, complaining, leisure behavior, physical activity, psychological and psychosocial fields, and other behavioral researches [14]. The TPB based entrepreneurship research has immensely developed in the last 20 years and has contributed to entrepreneurship behavioral understanding [23]. In the university scope, some entrepreneurship researches concluded that attitude, subjective norms, and perceived behavioral control contribute significantly toward entrepreneurship interest and have the capability to encourage entrepreneurship behavior [3, 24, 25]. The other influencing factors are entrepreneurship education [26-31]. However, attitude is the strongest influencing variable [3] that possess cognitive and affective dimension to generate different impact toward entrepreneurship interest [32].

In student entrepreneurial related research, the TPB has also been used as well to explain and predict the planned behavior, such as to study entrepreneurial intentions [41], to explain and measure the student entrepreneurial intention of the first and the fourth year of business student [43], to study entrepreneurial intention through the moderation effect of start-up experience [42], to study the intention-action gap as the extent of TPB through the moderating role of entrepreneurial motivation between intention and behavior [40], and to study the relationship between intention and behavior based on the TPB to determine the level of student entrepreneurial motivation [39].

3. Methodology

3.1 Dataset

This study uses the Indonesian higher education dataset that is provided by the Indonesian Ministry of Research, Technology and Higher Education.

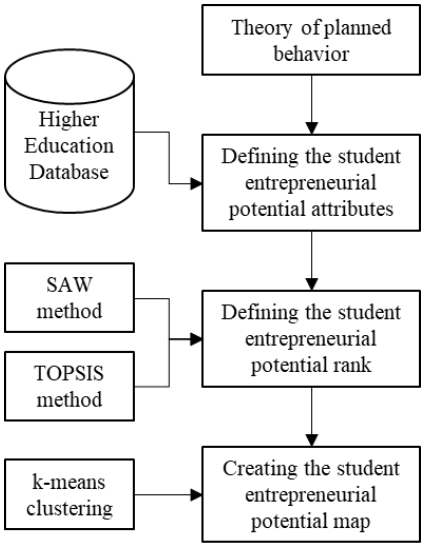

Figure. 2 The proposed method for the student entrepreneurial potential map

This dataset is public and it is the education standard in Indonesia according to the passing law no. 12/2012 on higher education. The Indonesian higher education database is a centralized database that contains all of the recent statistics and information about higher education, such as students, lecturers, study programs, and universities in Indonesia.

3.2 Methods

The goal of this study is to design the student entrepreneurial potential mapping through the integration of decision making and clustering methods. The first stage of this study is defining the student attributes based on the TPB from the higher education database. The second stage is performing the student entrepreneurial potential rank using the FMADM method. Whilst, the third stage is grouping the student into the entrepreneurial potential clusters as the student entrepreneurial potential mapping. Overall, the proposed method to generate the student entrepreneurial potential map in this study is summarized in Fig. 2. The detail of the proposed method is explained step by step in the following sub-sections as follows.

3.2.1. Defining the student entrepreneurial potential attributes

The purpose of this stage is selecting the student attributes from the higher education database that represents the student entrepreneurial potential based on the TPB. There are three beliefs in the TPB construction that influence the student entrepreneurial intention. These beliefs are attitude, subjective norms, and perceived behavioral control [35]. Based on the higher education database, there

are 14 student attributes, which can be categorized into the main three beliefs in the TPB [8].

The attitude belief can be represented through three attributes, which are the scholarship status, activist status, and type of entry. These attributes usually affect the attitude of students in behavior. Scholarships students generally have a higher attitude as the positive responsibilities form to their sponsors. Students who have an activity in the student organization generally have higher attitude concerns as their integrity as an activist. Whereas students who have higher competency when entering the university generally have a significant correlation to their attitudes.

The subjective norms belief can be represented through nine attributes, which are the parent occupation, parent income, grade point average (GPA), Indonesian language course score, English course score, research method course score, professional ethics course score, counseling course score, entrepreneurship course score. As a part the external factors to the entrepreneurial behavior, these attributes can be identified from the family and campus environments. The first two attributes, which are the parent occupation and income will influence the student decisions to perform the behavior. While the last nine attributes will affect the student's self-confidence in entrepreneurial behavior.

The perceived behavioral control can be represented through the business incubator status and college student entrepreneurship program (CSEP) status. These attributes are national competition programs from the government, which are designed to improve the student entrepreneurial abilities. Students who pass in these selection programs can be perceived as having fundamental abilities as prospective entrepreneurs. Thus, these selected attributes can represent the perceived behavioral control belief in the TPB model construction. All of these attributes that are defined from the higher education database and its relationships to the TPB beliefs are summarized in Table 1 [8, 16].

All of the defined attributes above are then used to construct the TPB model for student entrepreneurial potential, which is illustrated in Fig. 3. The student entrepreneurial potential in this study is constructed through the student entrepreneurial intention.

3.2.2. Defining the student entrepreneurial potential rank

Table 1. TPB beliefs components and defined attributes from the higher education database

No.	TPB Beliefs	Attributes
1.	Attitudes	Scholarship status, activists status, type of entry
2.	Subjective norms	Parents occupation, parents income, GPA, Indonesian language course score, English course score, research method course score, professional ethics course score, counseling course score, entrepreneurship course score
3.	Perceived behavioral control	Business incubator status, CSEP status

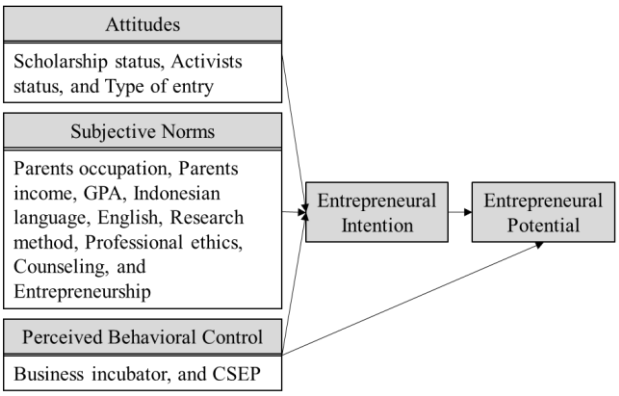

Figure. 3 The proposed TPB model construction for student entrepreneurial potential

The university management must do the decision making to create a policy in the student entrepreneurial programs. However, there are many limitations of resources to make a policy for all students. Hence, the managements require to select the potential student to run the student entrepreneurial programs policy effectively.

Unfortunately, the Indonesia higher education database contains many attributes that could not be generalized directly to select the student entrepreneurial potential. There is no decision support system model recently that can be used for decision making in the student entrepreneurial potential.

Based on the proposed TPB model in Fig. 1, the student entrepreneurial potential needs a decision making support system to accommodate all of the student entrepreneurial attributes and beliefs. The multiple criteria decision making (MCDM) perhaps the relevant method to overcome this situation [6]. Unfortunately, some of the attributes also contain either uncertainty or incomplete data. These two steps are needed to solve those issues, which are forming rank on each alternative based on

Table 2. Student entrepreneurial potential criteria

No	Criteria	Code
1.	Scholarship status	A1
2.	Activist status	A2
3.	Type of entry	A3
4.	Parents occupation	A4
5.	Parents income	A5
6.	GPA	A6
7.	Indonesian language course score	A7
8.	English course score	A8
9.	Research method course score	A9
10.	Professional ethics course score	A10
11.	Counseling course score	A11
12.	Entrepreneurship course score	A12
13.	Business incubator status	A13
14.	CSEP status	A14

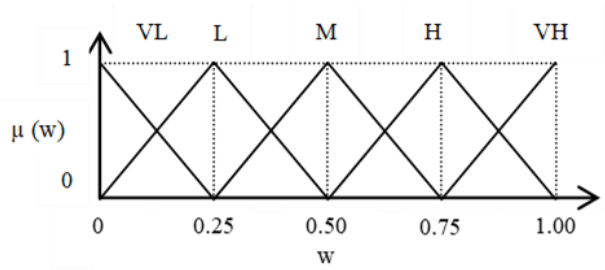

Figure. 4 Membership function for each Student entrepreneurial potential criteria

compatibility degree aggregate on all criteria, and ranking all alternative to obtaining the best alternative through de-fuzzy or fuzzy preference.

The level of student entrepreneurial potential criteria in this study are defined in Table 2, which are generated from the student entrepreneurial attributes in Table 1.

Each criterion will have a pre-determined variable and converted into a fuzzy number, as shown in Fig. 4. All of criteria are converted into the crisp numbers in the range of 0 to 1 with linguistic variable and fuzzy numbers as follows: very low (VL) = 0; low (L) = 0.25; medium (M) = 0.5; high (H) = 0.75, and very high (VH) = 1.

The membership function for each linguistic variable is represented by a triangular fuzzy number. The VL variable has fuzzy number of {0.00; 0.00; 0.25}, the L variable has fuzzy number of {0.00; 0.25; 0.50}, the M variable has fuzzy number of {0.25; 0.50; 0.75}, the H variable has fuzzy number of {0.50; 0.75; 1.00}, and the VH variable has fuzzy number of {0.75; 1.00; 1.00}. The complete criteria, linguistic variables, and fuzzy numbers are listed in Table 3. After the linguistic variables and fuzzy numbers of criteria are defined, the composite SAW and TOPSIS method are then applied to determine the student entrepreneurial potential rank.

Table 3. Criteria code, linguistic variable, and fuzzy number

Criteria Code	Linguistic Variable	Fuzzy Number
A1	Very High	(0.75; 1.00; 1.00)
A2	Very High	(0.75; 1.00; 1.00)
A3	High	(0.50; 0.75; 1.00)
A4	High	(0.50; 0.75; 1.00)
A5	Low	(0.00; 0.25; 0.50)
A6	Medium	(0.25; 0.50; 0.75)
A7	Low	(0.00; 0.25; 0.50)
A8	Low	(0.00; 0.25; 0.50)
A9	Medium	(0.25; 0.50; 0.75)
A10	Low	(0.00; 0.25; 0.50)
A11	Low	(0.00; 0.25; 0.50)
A12	Medium	(0.25; 0.50; 0.75)
A13	High	(0.50; 0.75; 1.00)
A14	High	(0.50; 0.75; 1.00)

3.2.2.1. Simple additive weighting (SAW)

The SAW method is a scoring method using a weighted linear combination based on the weighted average using some criteria. The evaluation score of each alternative is computed by the weighted sum of performance ratings. The SAW method is summarized in Algorithm 1, as follows.

Algorithm 1: SAW algorithm

Input: Value set $\{x_1, x_2, \dots, x_i\}$ of alternative A_i.
Output: Alternative preference values V_i.

Step 1. Define alternatives $\{A_1, A_2, \dots, A_i\}$.
Step 2. Define criteria for references in decision making $\{C_1, C_2, \dots, C_j\}$.
Step 3. Define the rating of each alternative on each criterion.
Step 4. Define the weight or level of importance for each criterion $\{w_1, w_2, \dots, w_j\}$.
Step 5. Calculate the normalized decision matrix r_{ij} using the following formula:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{\max(x_j)} & \text{for positive criteria} \\ \frac{\min(x_j)}{x_{ij}} & \text{for negative criteria} \end{cases} \quad (4)$$

where $i = 1,2, \dots, m$; $j = 1,2, \dots, n$, x_j is the value of attribute x in column j, and x_{ij} is the value of attribute x in the row i and column j.

Step 6. Compute the alternative preference value V_i using the following formula:

$$V_i = \sum_{j=1}^{n} w_j r_{ij} \quad (5)$$

Through the SAW method, the alternative will be ranked by the sum of weighted values for all criteria. The preferred alternatives are indicated by the larger value of V_i. The defined value and weighted preference for alternatives in the SAW algorithm could generate the decision precisely.

3.2.2.2. Technique for order preference by similarity to ideal solution (TOPSIS)

The TOPSIS method is a method to select the best alternative, which is closest to the positive ideal solution and farthest to the negative ideal solution [21]. In decision making, the best alternative or the ideal solution is an alternative with a higher value and it can be used to make a decision. TOPSIS is commonly used because it has a simplicity to understand the concept, efficient in computation, and capability to measure the relative performance of decision alternatives on the simple mathematical form. The TOPSIS method is summarized in Algorithm 2, as follows.

Algorithm 2: The TOPSIS algorithm

Input: Performance ratings r_{ij} for each alternative A_i that are normalized on C_j, that is:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (6)$$

Output: Alternative preference values V_i.

Step 1. Compute the normalized decision matrix for each alternative using weighted of each criterion:

$$y_{ij} = w_i r_{ij} \quad (7)$$

Step 2. Compute the highest value A^+as the ideal positive solution and the lowest value A^- as the negative ideal solution, as follows:

$$A^+ = (y_1^+, y_2^+, \dots, y_m^+) \quad (8)$$

$$A^- = (y_1^-, y_2^-, \dots, y_m^-) \quad (9)$$

where y_j^+ is the maximum of y_{ij} if j is the positive attribute, and y_j^+ is the minimum of y_{ij} if j is the negative attribute, Otherwise, y_j^- is the minimum of y_{ij} if j is the negative attribute, and y_j^- is the maximum of y_{ij} if j is the positive attribute.

Step 3. Determine the distance of each alternative to the ideal positive solution (D_i^+) and negative ideal solution (D_i^-).

$$D_i^+ = \sqrt{\sum_{i=1}^{n} (y_i^+ - y_{ij})^2} \quad (10)$$

$$D_i^- = \sqrt{\sum_{i=1}^{n} (y_{ij} - y_i^-)^2} \quad (11)$$

Step 4. Compute the alternative preference value V_i using the following formula:

$$V_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (12)$$

3.2.2.3. The composite of SAW and TOPSIS

As explained in Section 3.2, the student entrepreneurial potential rank in this study will be determined using the composite of the SAW and TOPSIS methods. This composite method is proposed based on the preliminary experiment on the SAW and TOPSIS methods in decision making. The SAW method has more precisely to generate the related alternatives based on the criteria and the level of important attributes. While the TOPSIS method has a good performance to select the best alternative solution by considering the positive and negative distances between the alternatives.

Based on these considerations above, this study proposes the composite of the SAW and TOPSIS methods to determine the student entrepreneurial potential rank, rather than using either the SAW only or the TOPSIS only. Technically, the SAW method is used to calculate the normalized decision matrix r_{ij} related to Step 1 to Step 5 in Algorithm 1. Whereas, the chosen of the best alternative solution uses the TOPSIS method related to Algorithm 2.

Algorithm 3: The SAW-TOPSIS algorithm

Input: Value set $\{x_1, x_2, \dots, x_i\}$ of alternative A_i.

Output: Alternative preference values V_i.

Step 1. Define alternatives $\{A_1, A_2, \dots, A_i\}$.

Step 2. Define criteria for references in decision making $\{C_1, C_2, \dots, C_j\}$.

Step 3. Define the rating of each alternative on each criterion.

Step 4. Define the weight or level of importance for each criterion $\{w_1, w_2, \dots, w_j\}$.

Step 5. Compute the normalized decision matrix for each alternative using Eq. (7)

Step 6. Compute the highest value A^+as the ideal positive solution and the lowest value A^-

as the negative ideal solution using Eq. (8) and Eq. (9), respectively.

Step 7. Determine the distance of each alternative to the ideal positive solution (D_i^+) and negative ideal solution (D_i^-) using Eq. (10) and Eq. (11), respectively.

Step 8. Compute the alternative preference value V_i using Eq. (12).

3.2.3. Creating the student entrepreneurial potential map

The student entrepreneurial potential rank in this stage will produce the rank of students based on the level of intention in entrepreneurial behavior. The next stage is creating the student entrepreneurial potential map, which will be used to present the student entrepreneurial potential completely. This student entrepreneurial potential map can be used as the decision support system for university management to take the student entrepreneurial policy. In this study, the $k-$means clustering method is applied to create the student entrepreneurial potential map though some related to the entrepreneurial intention clusters.

Algorithm 4: The k-means clustering algorithm

Input: Value set $\{x_1, x_2, \dots, x_i\}$ of alternative A_i and the number of initial clusters k.

Output: A set of k clusters.

Step 1. Choose k data items from $\{x_1, x_2, \dots, x_i\}$ as the initial centroids.

Step 2. Assign each item data x to the cluster that has the closest centroid.

Step 3. Calculate new arithmetic mean for each cluster.

Step 4. Repeat step 2 and step 3 until satisfying the convergence criteria.

The $k-means$ clustering is chosen as a part of the proposed method because this study uses five linguistic variables, which are very low, low, medium, high, and very high, which can be used as the initial cluster numbers. The brief of the $k-$means clustering method is performed using Algorithm 4.

4. Results and discussion

The objective of this study is mainly to create the student entrepreneurial potential map using the SAW-TOPSIS and $k-means$ clustering methods based on the TPB model that is proposed in the previous section. The experimental of this study is conducted and analyzed intensively to evaluate the proposed method. This study uses the Indonesia higher education database from 2009 to 2015 years as the experimental dataset based on the true status of the CSEP attribute. The CSEP attribute is a specific student attribute that represents the intention of students to join the student entrepreneurial program, which is offered by the government. There are 336 students with the true status of CSEP attributes, which are 273 in proposing status and 63 in funded status. The first stage in this experiment is defining the alternatives, criteria, and weight of each criterion associates with step 1 to step 3 in Algorithm 3. The results of these steps are summarized in Table 4.

Table 4. Alternative, criteria, and weight of attribute

Code	Alternative	Criteria	Weight
A1	Scholarship status	Scholarship	1
		Non-scholarship	0.25
A2	Activist status	Activist	1
		Non-activist	0.25
A3	Type of entry	Non-regular	1
		AVG>7	0.75
		Regular test	0.5
		Transfer	0.25
		Moving	0
A4	Parents occupation	Entrepreneur	1
		Non-entrepreneur	0.25
A5	Parents income	> 10 million	1
		7-10 million	0.75
		5-7 million	0.5
		3-5 million	0.25
		< 3 million	0
A6	GPA	Cum laude	1
		High satisfactory	0.75
		Satisfying	0.5
		Good	0.25
Course Score:			
A7	Indonesian language	A	1
A8	English	B	0.75
A9	Research method	C	0.5
A10	Professional ethics	D	0.25
A11	Counseling	E	0
A12	Entrepreneurship		
A13	Business incubator status	Member	1
		Non-member	0.25
A14	CSEP status	Excellent	1
		Funded	0.75
		Proposing	0.5

There are 14 selected attributes from the higher education dataset related to the TPB beliefs that are

Table 5. Compatibility rating of each alternative

Instance	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
1	1	0.25	0.5	0.25	0.5	0.75	1	0.75	1	0.75	1	0.75	0.25	0.5
2	1	0.25	0.5	1	0.75	0.5	1	0.75	0.75	1	1	0.75	1	0.5
3	0.25	0.25	0.5	1	0.25	0.5	1	0.5	0.75	1	1	0.75	1	0.75
4	1	0.25	0.5	0.25	0.75	0.5	0.75	0.5	0.75	0.75	1	1	0.25	0.5
…	…	…	…	…	…	…	…	...	...	...	...	...	...	...
333	1	1	0.5	0.25	0	1	1	0.75	0.75	0.5	0.75	1	0.25	0.5
334	0.25	0.25	0.5	0.25	0	0.25	0.75	0.75	0.75	0.5	0.75	0.75	0.25	0.5
335	0.25	0.25	0.5	1	0.75	0.75	0.75	0.75	1	0.5	1	1	0.25	0.5
336	0.25	0.25	0.5	1	0.5	0.75	0.5	0.75	1	0.5	0.75	0.75	1	0.5

attitude, subjective norms, and perceived behavioral control as described in Table 1. Each attribute will be used as an alternative solution for decision making. To apply the SAW-TOPSIS method, the criteria of each alternative are defined from the dataset. Besides, the weights of criteria are defined using the fuzzy membership function. The criterion weighting is done through manual analysis with the university management. As shown in Table 4, there is a one-to-one relationship between the criteria and its weight to achieve the certain data value of attributes and to address the fuzziness of the dataset.

The selected variable from the Indonesia higher education database is relevant because it is similar to the individual attributes in the Global Entrepreneurship Monitor (GEM) dataset which are indicators of demographic characteristics (gender, age, etc.), self-perception (capability perception, perception of opportunity, fear of failure) and motivation to start a business [15]. Following the entrepreneurship process model developed by GEM, the first step is to grow potential entrepreneurs by providing business opportunities and providing adequate knowledge and skills. The TPB studies on entrepreneurship in the student environment prove that attitude, subjective norms and perceived behavioral control [3, 25], which is integrated with entrepreneurship education would be able to have a positive and significant influence on the increasing entrepreneurial intentions of students and creating entrepreneurial behavior [27-31].

The next step is defining the weight or level of importance for each criterion associated with step 4 in Algorithm 2. This step requires the compatibility rating of each alternative, as defined in Table 5. Using Table 4, Table 5, and the fuzzy number in Table 3, the decision matrix can be obtained using Eq. (3) that gives the result as follows.

$$r_{ij} = \begin{pmatrix} 1 & 0.25 & 0.5 & 0.25 & \cdots & 1 & 0.75 & 0.25 & 0.5 \\ 1 & 0.25 & 0.5 & 0.25 & \cdots & 1 & 0.75 & 1 & 0.5 \\ 0.25 & 0.25 & 0.5 & 1 & \cdots & 1 & 0.75 & 1 & 0.75 \\ 1 & 0.25 & 0.5 & 1 & \cdots & 1 & 1 & 0.25 & 0.5 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & 1 & 0.5 & 0.25 & \cdots & 0.75 & 1 & 0.25 & 0.5 \\ 0.25 & 0.25 & 0.5 & 0.25 & \cdots & 0.75 & 0.75 & 0.25 & 0.5 \\ 0.25 & 0.25 & 0.5 & 1 & \cdots & 1 & 1 & 0.25 & 0.5 \\ 0.25 & 0.25 & 0.5 & 1 & \cdots & 0.75 & 0.75 & 0.25 & 0.5 \end{pmatrix}$$

This decision matrix gives the preference weight for each criterion, so the generated weight vector is: w_j = [1, 1, 0.75, 0.75, 0.25, 0.25, 0.50, 0.25, 0.50, 0.25, 0.25, 0.25, 0.75, 0.75]. The normalized decision matrix for each alternative related to step 5 in Algorithm 3 is then computed using Eq. (6), which gives the result as follows.

$$y_{ij} = \begin{pmatrix} 1 & 0.25 & 0.375 & 0.1875 & \cdots & 0.25 & 0.375 & 0.1875 & 0.375 \\ 1 & 0.25 & 0.375 & 0.75 & \cdots & 0.25 & 0.375 & 0.75 & 0.375 \\ 0.25 & 0.25 & 0.375 & 0.75 & \cdots & 0.25 & 0.375 & 0.75 & 0.5625 \\ 1 & 0.25 & 0.375 & 0.1875 & \cdots & 0.25 & 0.5 & 0.1875 & 0.375 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 1 & 1 & 0.375 & 0.1875 & \cdots & 0.1875 & 0.5 & 0.1875 & 0.375 \\ 0.25 & 0.25 & 0.375 & 0.1875 & \cdots & 0.1875 & 0.375 & 0.1875 & 0.375 \\ 0.25 & 0.25 & 0.375 & 0.75 & \cdots & 0.25 & 0.5 & 0.1875 & 0.375 \\ 0.25 & 0.25 & 0.375 & 0.75 & \cdots & 0.1875 & 0.375 & 0.75 & 0.375 \end{pmatrix}$$

The matrix y_{ij} leads the y_j^+ and y_j^- values that are obtained using Eq. (7) and Eq. (8), respectively, which are presented in Table 6. The next step is determining the distance of alternative toward a positive and negative ideal solution using Eq. (9) and Eq. (10) associated with step 7 in Algorithm 3. The results of this step are presented in Table 7, where all of the values are obtained by moving and arranging both the max and the min values. The last step of applying the SAW-TOPSIS method is finding the preference value of each alternative using Eq. (11). This step is associated with step 8 in Algorithm 3. The results of the preference value V_i are presented in Table 8. While the preference value rank based on the ordered preference value is presented in Table 9.

Table 6. A positive and negative ideal solution

Positive Ideal Solution		Negative Ideal Solution	
Code	**Score**	**Code**	**Score**
y1+	0.5000	y1-	0.1250
y2+	1.0000	y2-	0.2500
y3+	1.0000	y3-	0.2500
y4+	0.7500	y4-	0.0000
y5+	0.7500	y5-	0.1875
y6+	0.2500	y6-	0.0000
y7+	0.2500	y7-	0.0000
y8+	0.2500	y8-	0.0000
y9+	0.5000	y9-	0.0000
y10+	0.2500	y10-	0.1250
y11+	0.2500	y11-	0.0000
y12+	0.5000	y12-	0.2500
y13+	0.7500	y13-	0.1875
y14+	0.7500	y14-	0.0000

Table 7. Alternative distance toward the positive and negative ideal solution

Positive Ideal Solution		Negative Ideal Solution	
Code	**Score**	**Code**	**Score**
D_1^+	1.2339	D_1^-	2.0584
D_2^+	0.9703	D_2^-	2.2930
D_3^+	1.1991	D_3^-	2.1133
D_4^+	1.2562	D_4^-	2.0175
---	---	---	---
D_{333}^+	1.0078	D_{333}^-	2.1955
D_{334}^+	1.5168	D_{334}^-	1.6607
D_{335}^+	1.3273	D_{335}^-	2.0329
D_{336}^+	1.2180	D_{336}^-	2.0885

The student entrepreneurial potential selection has been performed using the composite SAW-TOPSIS based on the FMADM approach. The most potential students can be selected through the preference values rank in Table 9. To address the limitation of organization resources, university management can select a certain number of the top potential students to implement the student entrepreneurial program. This student selection can be used as part of the decision making in the student entrepreneurial policy.

Table 8. Preference values of all instance

Code	Values
V_1	0.6252
V_2	0.7027
V_3	0.6380
V_4	0.6163
---	---
V_{333}	0.6854
V_{334}	0.5226
V_{335}	0.6050
V_{336}	0.6316

Table 9. Preference values rank of all instance

Instance	Rank	Values
60	1	0.8619
129	2	0.8277
230	3	0.8216
130	4	0.8116
---	---	---
275	333	0.5088
249	334	0.5088
254	335	0.5064
253	336	0.4937

Table 10. Data distribution of successful students in the CSEP participation

Potential Level	Total of Students	Total of Success	Percentage (%)
Medium	178	23	13
High	148	34	23
Very High	10	6	60
Total	**336**	**63**	

Figure. 5 Relationship level of entrepreneurial potential

The student entrepreneurial potential in Table 9 is then categorized into the medium, high dan very high three potential levels based on the V_i range of values, which are defined as follows:

a. Medium (M) level for $0.4937 \leq V_i \leq 0.6164$;
b. High (H) level for $0.6165 \leq V_i \leq 0.7392$;
c. Very high (VH) level for $0.7393 \leq V_i \leq 0.8620$.

The length of each level is defined using the $length = \{\max(V_i) - \min(V_i)\}/k$ with k is the number of level classes. Based on the V_i values in Tabel 9, the length of each level class is 0.1228. The data distribution of the student entrepreneurial potential who are successful to obtain the CSEP to the total students is shown in Table 10.

The relationship between the entrepreneurial potential level with CSEP achievement is illustrated in Fig. 5. It shows that the entrepreneurial potential level is inversely potential to the sum of the students. The higher entrepreneurial potential level only followed by a smaller number of students. However, the chance of students to gain the CSEP is getting higher. In other words, the student entrepreneurial potential level is equivalent to the CSEP achievement. Hence, the composite SAW-TOPSIS method is feasible to be used as the student entrepreneurial potential reference.

Finally, to complete the representation of the student entrepreneurial behavior, the $k-$means clustering is applied to group the potential students into the student entrepreneurial behavior map. The clustering process using the $k-$means clustering produces the optimal student groups in the four clusters based on the predefined linguistic variables.

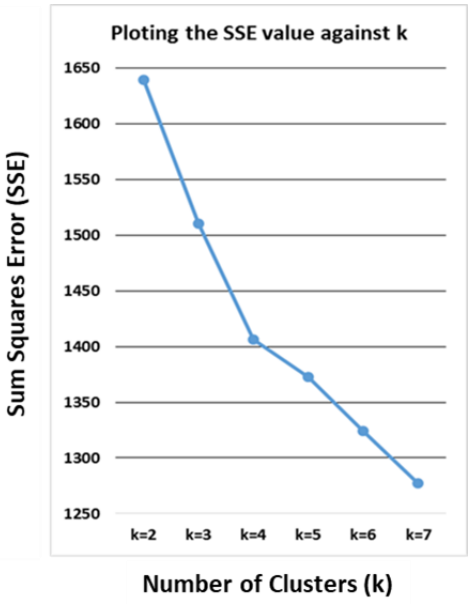

Figure. 6 Plotting SSE

The clustering experiment was conducted to cluster 2's to 7's size with a random seed $s = 10$. The clustering results for each combination $k$and s were evaluated by a sum of squares error (SSE) total. The SSE total is sufficient to evaluate clusters since it minimizes equivalent SSE by maximizing the sum of squares between (SSB) clusters.

Fig. 6 shows the plotting of the SSE total value for each k. The SSE value is decreasing as the cluster size is increasing. It is synchronous with $k-$means algorithm characteristic.

On the SSE total criteria, the best clustering distance will select total clusters as many as an object [36]. The number of cluster characteristics could be found within the experimental data by looking at the cluster size as knee, peak, or dip within plot graphic of evaluation scale to cluster size are found [37]. As shown in Fig. 6, the distinct knee of the clusters is on the $k = 4$, so it can be concluded that the best number of clusters in this study is about 4 clusters or $k = 4$, namely $cls0, cls1, cls2,$ and $cls4$.

The summary of the clustering results is described in Table 11, which can be discussed as follows:

a. Cluster $cls0$ is produced using the centroids of many criteria values, which are: A1='not-scholarship', A2='not-activists', A3='AVG>7.0', A4='not-entrepreneurs', A5='less than 3 million', A6='satisfying', A7='B', A8='B", A9='A', A10='C', A11='A', A12='A', A13='member', and A14='proposing'. The centroid score of this cluster is 0.5485, hence this cluster can be categorized as a cluster with a medium level of entrepreneurial potential. In the attitude belief, the members of this cluster do not have a stand-out attitude belief (not-scholarship and not activist) and originated from a non-test registration path (AVG>7). In the subjective norms belief, the members of this cluster possess satisfying academic achievement and come from a non-entrepreneurs family with less than 3 million monthly incomes. In the perceived behavior control belief, the members of this cluster have positive perception toward entrepreneurship because they are a member of a business incubator program.

Table 11. Summary of the student entrepreneurial potential

Cluster	Instances	Centroid Attributes	Centroid Scores	Potential Level
cls0	114	Not-scholarship, not-activists, AVG > 7.0, not-entrepreneurs, less than 3 million, satisfying, B, B, A, C, A, A, member, proposing	0.5485	Medium
cls1	132	Scholarship, non-activists, regular test, not-entrepreneurs, 3-5 million, highly satisfactory, A, B, B, C, A, A, non-member, proposing	0.6186	High
cls2	36	Scholarship, activists, regular, not-entrepreneurs, 5 – 7 million, cum laude, A, B, A, C, A, A, member, proposing	0.7520	Very High
cls3	54	Not-scholarship, activists, non-regular selection, not-entrepreneurs, 3-5 million, highly satisfactory, B, B, B, C, A, A, member, proposing	0.6798	High

b. Cluster $cls1$ is produced using the centroids of many criteria values, which are: A1='scholarship', A2='non-activist', A3='regular test', A4='not entrepreneurs', A5='3-5 million', A6='highly satisfactory', A7='A', A8='B', A9='B', A10='C', A11='A', A12='A', A13='non-member', and A14='proposing'. The centroid score of this cluster is 0.5485, hence this cluster can be categorized as a cluster with a high level of entrepreneurial potential. In the attitude belief, the members of this cluster have a good academic attitude by becoming a scholarship grantee and are originated from a regular registration path. In the subjective norms belief, the members of this cluster have a highly satisfactory academic achievement and come from a non-entrepreneurs family with 3-5 million monthly incomes. However, the members of this cluster have a negative perception control toward entrepreneurship since they are not a member of a business incubator program.
c. Cluster $cls2$ is produced using the centroid of many criteria values, which are: A1='scholarship', A2='activists', A3='regular test', A4='not-entrepreneurs', A5='5-7 million', A6='cumlaude', A7='A', A8='B', A9='A', A10='C', A11='A', A12='A', A13='member', and A14='proposing'. This cluster has 0.7520 of the centroid score, hence the cluster C2 can be categorized as a cluster with a very high entrepreneurial potential. In the attitude belief, the members of this cluster have attitude characteristics that are academic attitude as the scholarship grantee, non-academic one as activists, and originated from the regular registration path. In the subjective norms belief, the members of this cluster have normative characteristics that are cum laude academic achievement and come from a non-entrepreneurs family with 5-7 million monthly incomes. In the perceived behavior control, the members of this cluster have positive perception because they are a member of a business incubator program.
d. Cluster $cls3$ is produced using the centroids of many criteria values, which are: A1='not-scholarship', A2='activist', A3='non-regular test selection', A4='not-entrepreneurs', A5='3-5 million', A6='highly satisfactory', A7='B', A8='B', A9='B', A10='C', A11='A', A12='A', A13='member', and A14='proposing'. This cluster has 0.6798 of the centroid score, hence this cluster is categorized as a cluster with high entrepreneurial potential. In the attitude belief, the members of this cluster have a good non-academic attitude by becoming activists and are originated from the non-regular selection path. In the subjective norms belief, the members of this cluster have a highly satisfactory academic achievement and come from a non-entrepreneurs family with 3-5 million monthly incomes. In the perceived behavior control, the members of this cluster have positive perception because they are a member of a business incubator program.

Some insightful knowledge could be exposed to the clustering results. There are two clusters with a high potential level, which are cluster $cls1$ with the centroid score of 0.6186 and cluster $cls3$ with the centroid score of 0.6798. The interesting part of these results is that the centroid score gap between the cluster $cls1$ (high level) and the cluster $cls0$ (medium level) is near to the centroid score gap of the cluster $cls3$ (high level) and the cluster $cls2$ (very high level), which is approximately about 0.07. Based on the observation, this distinction is influenced by two prominent beliefs that are attitude belief with scholarship status, activist status attributes, and the perceived behavior control belief with the business incubator status attribute.

Related to the CSEP, the achievement of each cluster and their respective entrepreneurial potential level is illustrated in Fig. 7, which are described as follows.

a. As many as 19% of members in the $cls0$ cluster (medium level) have the optimum achievement on the CSEP, which are contributed by the medium and high potential levels of 68% and 32%, respectively.
b. As many as 12% of members in the $cls1$ cluster (high level) have the optimum achievement on the CSEP, which are contributed by the medium, high and very high potential levels of 19%, 69%, and 12%, respectively.
c. As many as 39% of members in the $cls2$ cluster (very high level) have the optimum achievement on the CSEP, which are contributed by the high and very high potential levels of 50% and 50%, respectively.
d. As many as 20% of members in the $cls3$ cluster (high level) have the optimum achievement on the CSEP, which are contributed by the medium and high potential levels of 18% and 82%, respectively.

Based on the two high potential level clusters, it can be seen that the $cls3$ cluster has better achievement than the $cls1$ cluster. The $cls3$ cluster itself has a closer centroid score to the $cls2$ cluster (very high level), while the $cls1$ cluster has a closer centroid score to the $cls0$ cluster (medium level).

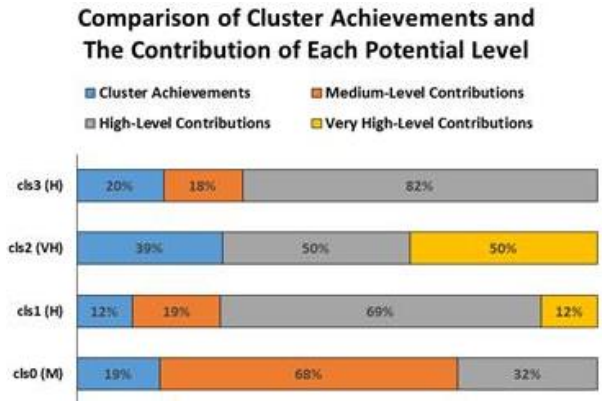

Figure. 7 Comparison of cluster achievements and the contribution of each potential level

Table 12. Approaches comparison of entrepreneurship analysis study

Ref.	Approaches					
	MADM	Fuzzy	Statistics	Clustering	Other	TPB
[8]	√	-	-	√	-	-
[9]	√	√	-	√	-	-
[15]	-	√	-	-	-	√
[23]	-	-	-	-	√	√
[25]	-	-	√	-	-	√
[26]	-	-	√	-	-	√
[32]	-	-	√	-	-	√
This study	√	√	-	√	-	√

Hence, it can be concluded that the two attributes of attitude belief, which are scholarship status and activist status, and the one attribute of perceived behavior control, which is business incubator status, possess a significant influence on the enhancement of the CSEP achievement.

Overall, the results of this study could be expected to improve the preliminary studies in the student entrepreneurial potential mapping. In the early study, the student entrepreneurial potential mapping has been identified through a combination of the simple multi-attribute rating technique and clustering methods [8]. However, that study does not consider the student behavior to select the related attributes. The use of TPB in this study could affect the potential level of cluster results, which has been produced by the multi-attribute rating technique and clustering methods. The distinction approaches used in this study compared to the other studies are summarized in Table 12.

Table 12 shows that this study does not only apply the TPB approach for certain beliefs analysis in the student entrepreneurial intention. However, this study also utilizes the fuzzy, MADM and clustering approaches to produce the student entrepreneurial potential mapping to support the university management for decision making.

5. Conclusions

The student entrepreneurial potential mapping using the integration of SAW-TOPSIS decision making and clustering models have been presented in this study. Experimental results show that the integration of the fuzzy SAW-TOPSIS and clustering method based on the TPB is suitable to evaluate the student entrepreneurial potential. The proposed method could recognize the relevant attributes of students that are required for university management to support decision making in the student entrepreneurial program policies.

This study also yields four identified clusters to present the student entrepreneurial potential levels. The first cluster consists of 19% of CSEP achievement students who have medium and high potential levels of 68% and 32%, respectively. The second cluster consists of 12% of CSEP achievement students who have medium, high and very high potential levels of 19%, 69%, and 12%, respectively. The third cluster consists of 39% of CSEP achievement students who have high and very high potential levels of 50% and 50%, respectively. While the fourth cluster consists of 20% of CSEP achievement students who have medium and high potential levels of 18% and 82%, respectively.

One of the important findings in this experiment is that the CSEP has a significant impact on the success of the student entrepreneurial program. The students who have funded in the CSEP will have a high chance to be an actual entrepreneur in the future. Besides, the students of CSEP have also a better attitude, subjective norms, and perceived behavior control beliefs rather than regular students.

For future work, the results of this study can be used as the initial points to identify and develop logical rules based on the student entrepreneurial potential mapping.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, N. Rijati; methodology, N. Rijati, and D. Purwitasari; software, N. Rijati; validation, N. Rijati, D. Purwitasari, S. Sumpeno, and M.H. Purnomo; formal analysis, N. Rijati, D. Purwitasari, S. Sumpeno, and M.H. Purnomo; investigation, N. Rijati, D. Purwitasari, S. Sumpeno, and M.H. Purnomo; resources, N. Rijati, and D.

Purwitasari; data curation, N. Rijati, and D. Purwitasari; writing—original draft preparation, N. Rijati; writing—review and editing, N. Rijati, and D. Purwitasari; visualization, N. Rijati; supervision, S. Sumpeno, and M.H. Purnomo; project administration, N. Rijati. All authors read and approved the final manuscript.

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