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MCDM Approach to Assess Innovation and Entrepreneurship Education in Higher Vocational Colleges under IndetermSoft Set

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Abstract: Innovation and entrepreneurship education has become an essential component of higher vocational colleges, aiming to cultivate students' creativity, problem-solving abilities, and business acumen. As the global economy increasingly prioritizes innovation-driven development, vocational institutions must ensure that their educational programs align with industry demands and entrepreneurial ecosystems. However, assessing the quality of innovation and entrepreneurship education remains a complex challenge due to the interdisciplinary nature of the field, the diverse skill sets required, and the rapidly evolving business environment. We use the concept of multi-criteria decision-making (MCDM) to deal with different criteria. Two MCDM methods are used in this study such as Entropy method to compute the criteria weights and the EDAS method to rank the alternatives. we use the IndetermSoft set to deal with indeterminacy in criteria values. We propose an application to show the validation of the proposed approach.

Keywords: MCDM Methodology; Innovation and Entrepreneurship; IndetermSoft Set; Education.

1. Introduction

Innovation and entrepreneurship education has emerged as a critical pillar in higher vocational colleges, bridging the gap between academic learning and real-world business practices. With the rapid advancement of technology and evolving market needs, vocational institutions must equip students with the necessary entrepreneurial mindset, technical skills, and problem-solving capabilities. Unlike traditional education, which primarily focuses on theoretical knowledge, innovation and entrepreneurship education emphasizes experiential learning, hands-on business projects, and industry collaboration[1], [2]. However, the effectiveness of such programs varies significantly, necessitating a structured evaluation framework to ensure quality and relevance. The assessment of innovation and entrepreneurship education in vocational colleges involves multiple dimensions, including curriculum design, faculty competency, access to entrepreneurial resources, and the integration of industry expertise. A well-structured curriculum must balance theoretical foundations with practical applications, offering students exposure to case studies, startup incubation programs, and real-world business challenges[3], [4]. Moreover, faculty expertise plays a crucial role in guiding students through the complexities of entrepreneurship, requiring educators to possess not only academic knowledge but also hands-on business experience. The absence of qualified instructors can significantly hinder the effectiveness of entrepreneurial education, limiting students' ability to transform innovative ideas into viable business ventures[5], [6]. Industry collaboration is another critical factor in evaluating the quality of innovation and entrepreneurship education. Strong partnerships between vocational colleges and businesses provide students with mentorship opportunities, internship placements, and access to industry networks. Without direct engagement with the entrepreneurial ecosystem, students may struggle to develop market-ready skills, reducing their employability and business success rates. Additionally, technological integration in entrepreneurship education, including digital tools, business simulation software, and online learning platforms, enhances the learning experience and prepares students for the digital economy[7], [8]. A lack of modern technological resources can create a disconnect between classroom learning and industry realities. Given the complexity of evaluating entrepreneurship education, Multi-Criteria Decision-Making (MCDM) methodologies offer a structured approach to ranking and assessing various programs. By considering multiple qualitative and quantitative criteria, MCDM techniques help in identifying the strengths and weaknesses of different vocational institutions[9], [10]. This systematic evaluation provides valuable insights for policymakers, educators, and industry stakeholders, facilitating the continuous improvement of innovation and entrepreneurship education.

Ultimately, enhancing the quality of entrepreneurship education in vocational colleges is essential for fostering a new generation of innovative thinkers and business leaders. As economies become increasingly reliant on startups and technological advancements, vocational institutions must refine their educational strategies to meet industry expectations. This study contributes to the discourse on vocational education quality assessment by offering a robust framework for evaluating entrepreneurship programs, ensuring that students receive the necessary skills and resources to thrive in a competitive business landscape

The main contributions of this study are organized as follows:

- We use the concept of IndetermSoft set to deal with indeterminacy in each value of criteria and sub criteria.
- Three cases of indeterminacy are used in this study to solve the indeterminacy.
- Two MCDM methods are used in this study.
- We use the Entropy method to compute the criteria weights.
- We use the EDAS method to rank the alternatives.
- Ranks of alternatives are analyzed by different cases.

The rest of this study is organized as follows:

- Section 2 shows the steps of the proposed approach with the IndetermSoft set.
- Section 3 shows the results of the proposed approach with the IndetermSoft set and three cases.
- Section 4 shows the conclusions of this study.

2. IndetermSoft-Entropy-EDAS Methodology

Smarandache [11], [12] presented an IndetermSoft Set to deal with indeterminacy in the values of the criteria. Let U be a universe discourse, H a non-empty subset of U, and P(H) the power set of H. let a be a criterion and A be a set of criteria values.

Then $F: A \rightarrow P(H)$ is called an IndetermSoft set if:

The set A, P(H) has some indeterminacy and there is a criteria value has indeterminacy value.

IndetermSoft set has some indeterminacy and it is an extension of determinate set[13], [14].

Entropy Method

Create a decision matrix between the criteria and alternatives[15], [16].

Normalize the decision matrix

$$y_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{1}$$

Compute the entropy value

$$e_j = -h \sum_{i=1}^{m} y_{ij} \ln y_{ij} \tag{2}$$

$$h = \frac{1}{\ln m} \tag{3}$$

Compute the criteria weights.

$$w_j = \frac{1-e_j}{\sum_{j=1}^{n} (1-e_j)} \tag{4}$$

EDAS Method

The EDAS Method is used to rank the alternatives[13], [17].

Compute the average solution

$$B_j = \frac{\sum_{i=1}^{m} x_{ij}}{m} \tag{5}$$

Compute the positive and negative distance from the average solution

$$PR_{ij} = \frac{\max\left(0, \left(y_{ij} - B_j\right)\right)}{B_j} \tag{6}$$

$$NR_{ij} = \frac{\max\left(0,\left(B_j - y_{ij}\right)\right)}{B_j} \tag{7}$$

$$PR_{ij} = \frac{\max\left(0,\left(B_j - y_{ij}\right)\right)}{B_j} \tag{8}$$

$$NR_{ij} = \frac{\max\left(0,\left(y_{ij} - B_j\right)\right)}{B_j} \tag{9}$$

Compute the weighted PR and NR

$$SPR_i = \sum_{j=1}^{n} PR_{ij}\, w_j \tag{10}$$

$$SNR_i = \sum_{j=1}^{n} NR_{ij}\, w_j \tag{11}$$

Compute the weighted normalized SPR and SNR

$$NSPR_i = \frac{SPR_i}{\max_i SPR_i} \tag{12}$$

$$NSNR_i = \frac{SNR_i}{\max_i SNR_i} \tag{13}$$

Compute the appraisal score

$$F_i = \frac{NSPR_i + NSNR_i}{2} \tag{14}$$

3. Results and Discussion

This section shows the results of the proposed approach. Three experts and decision makers are invited to evaluate the criteria and alternatives. Nine criteria and ten alternatives are used in this study such as: Curriculum Design (Comprehensive, Basic), Entrepreneurial Resources Support (Extensive), Faculty Competency (Highly Skille), Practical Training Opportunities (Sufficient), Industry Collaboration (Strong), Graduate Employment and Startup Rate (High), Technology Integration (Advanced), Funding and Financial Support (High), Student Innovation Ability (High). The alternatives of this study are Cross-Disciplinary Innovation and Startup Support, Comprehensive Entrepreneurial Program, Student-Led Business Project Platform, Vocational College Startup Fund Program, Online and Offline Blended Entrepreneurship Course, Hands-On Entrepreneurial Training Initiative, Industry-Focused Innovation Hub, Government-Supported Startup Incubator, Technology-Driven Business Accelerator, Public-Private Partnership for Entrepreneurship

In this study, we show indeterminacy in the first criterion. So, we use the concept of the IndetermSoft soft set to deal with this indeterminacy. So, we apply the MCDM methods with this indeterminacy with three cases.

In the first case, we select the Comprehensive.

In the second case, we select the Basic.

In the third case, we select Comprehensive and Basic.

The first case:

We create a decision matrix between the criteria and alternatives.

We normalize the decision matrix using Eq. (1) as shown in Table 1.

Then we compute the entropy value using Eq. (2).

Then we compute the criteria weights using Eq. (4).

Table 1. Normalized values by Entropy method.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.10152	0.078799	0.121052	0.108129	0.100532	0.105299	0.100216	0.101312	0.1128
A_2	0.145741	0.08917	0.065636	0.081256	0.11071	0.105033	0.096898	0.068121	0.0845
A_3	0.080226	0.093587	0.121052	0.108129	0.092389	0.093742	0.105062	0.09997	0.1267
A_4	0.108927	0.06896	0.089665	0.108403	0.05388	0.110227	0.072817	0.122512	0.1125
A_5	0.11333	0.116648	0.111998	0.091951	0.111291	0.083902	0.135109	0.117725	0.0775
A_6	0.078547	0.132337	0.085789	0.084623	0.120043	0.095829	0.100216	0.082828	0.0846
A_7	0.145741	0.105007	0.079581	0.072802	0.086144	0.100756	0.10169	0.114181	0.0775
A_8	0.072053	0.091903	0.082488	0.141018	0.128185	0.105181	0.084926	0.084716	0.1128
A_9	0.063836	0.118731	0.126215	0.122433	0.098288	0.091404	0.105062	0.088393	0.0845
A_{10}	0.090078	0.104859	0.116525	0.081256	0.098538	0.108628	0.098004	0.120242	0.1267

Then we compute the average solution using Eq. (5).

Then we compute the positive and negative distance from the average solution suing Eqs. (6-9) as shown in Table 2 and 3.

Then we compute the weighted PR and NR using Eqs. (10 and 11).

Then we compute the weighted normalized SPR and SNR using Eqs. (12 and 13).

Then we compute the appraisal score using Eq. (14).

Table 2. PR_{ij} values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.015197	0	0.21052	0.081287	0.005317	0.05299	0.002157	0.013117	0.127537
A_2	0.457413	0	0	0	0.107095	0.050326	0	0	0
A_3	0	0	0.21052	0.081287	0	0	0.05062	0	0.266816
A_4	0.089268	0	0	0.084029	0	0.102265	0	0.225115	0.124685
A_5	0.133298	0.166477	0.119977	0	0.112911	0	0.351089	0.17725	0
A_6	0	0.323366	0	0	0.200426	0	0.002157	0	0
A_7	0.457413	0.050066	0	0	0	0.007562	0.016901	0.141807	0
A_8	0	0	0	0.410182	0.281849	0.051806	0	0	0.127537

A_9	0	0.187307	0.262151	0.224331	0	0	0.05062	0	0
A_{10}	0	0.048588	0.165248	0	0	0.086284	0	0.202425	0.266816

Table 3. NR_{ij} values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0	0.212008	0	0	0	0	0	0	0
A_2	0	0.108301	0.343639	0.187435	0	0	0.031016	0.318792	0.154822
A_3	0.197738	0.06413	0	0	0.076105	0.062579	0	0.000298	0
A_4	0	0.310396	0.103352	0	0.4612	0	0.271829	0	0
A_5	0	0	0	0.080495	0	0.160982	0	0	0.224699
A_6	0.214526	0	0.142113	0.153769	0	0.041714	0	0.171718	0.154347
A_7	0	0	0.204191	0.271982	0.138557	0	0	0	0.224699
A_8	0.279466	0.080971	0.17512	0	0	0	0.15074	0.152837	0
A_9	0.361636	0	0	0	0.017115	0.085959	0	0.116069	0.154822
A_{10}	0.099222	0	0	0.187435	0.014623	0	0.019958	0	0

The second case:

We create a decision matrix between the criteria and alternatives.

We normalize the decision matrix using Eq. (1) as shown in Table 4.

Then we compute the entropy value using Eq. (2).

Then we compute the criteria weights using Eq. (4).

Table 4. Normalized values by Entropy method.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.10152	0.102272	0.121052	0.108129	0.100532	0.105299	0.100216	0.101312	0.112754
A_2	0.145741	0.11921	0.065636	0.081256	0.11071	0.105033	0.096898	0.068121	0.084518
A_3	0.080226	0.115868	0.121052	0.108129	0.092389	0.093742	0.105062	0.09997	0.126682
A_4	0.108927	0.075002	0.089665	0.108403	0.05388	0.110227	0.072817	0.122512	0.112469
A_5	0.11333	0.075002	0.111998	0.091951	0.111291	0.083902	0.135109	0.117725	0.07753
A_6	0.078547	0.112526	0.085789	0.084623	0.120043	0.095829	0.100216	0.082828	0.084565
A_7	0.145741	0.122551	0.079581	0.072802	0.086144	0.100756	0.10169	0.114181	0.07753
A_8	0.072053	0.112526	0.082488	0.141018	0.128185	0.105181	0.084926	0.084716	0.112754
A_9	0.063836	0.05624	0.126215	0.122433	0.098288	0.091404	0.105062	0.088393	0.084518
A_{10}	0.090078	0.108802	0.116525	0.081256	0.098538	0.108628	0.098004	0.120242	0.126682

Then we compute the average solution using Eq. (5).

Then we compute the positive and negative distance from the average solution suing Eqs. (6-9) as shown in Table 5 and 6.

Then we compute the weighted PR and NR using Eqs. (10 and 11).

Then we compute the weighted normalized SPR and SNR using Eqs. (12 and 13).

Then we compute the appraisal score using Eq. (14).

Table 5. PR_{ij} values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.015197	0.022717	0.21052	0.081287	0.005317	0.05299	0.002157	0.013117	0.127537
A_2	0.457413	0.192097	0	0	0.107095	0.050326	0	0	0
A_3	0	0.158681	0.21052	0.081287	0	0	0.05062	0	0.266816
A_4	0.089268	0	0	0.084029	0	0.102265	0	0.225115	0.124685
A_5	0.133298	0	0.119977	0	0.112911	0	0.351089	0.17725	0
A_6	0	0.125264	0	0	0.200426	0	0.002157	0	0
A_7	0.457413	0.225513	0	0	0	0.007562	0.016901	0.141807	0
A_8	0	0.125264	0	0.410182	0.281849	0.051806	0	0	0.127537
A_9	0	0	0.262151	0.224331	0	0	0.05062	0	0
A_{10}	0	0.088016	0.165248	0	0	0.086284	0	0.202425	0.266816

Table 6. NR_{ij} values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0	0	0	0	0	0	0	0	0
A_2	0	0	0.343639	0.187435	0	0	0.031016	0.318792	0.154822
A_3	0.197738	0	0	0	0.076105	0.062579	0	0.000298	0
A_4	0	0.249977	0.103352	0	0.4612	0	0.271829	0	0
A_5	0	0.249977	0	0.080495	0	0.160982	0	0	0.224699
A_6	0.214526	0	0.142113	0.153769	0	0.041714	0	0.171718	0.154347
A_7	0	0	0.204191	0.271982	0.138557	0	0	0	0.224699
A_8	0.279466	0	0.17512	0	0	0	0.15074	0.152837	0
A_9	0.361636	0.437598	0	0	0.017115	0.085959	0	0.116069	0.154822
A_{10}	0.099222	0	0	0.187435	0.014623	0	0.019958	0	0

The third case:

We create a decision matrix between the criteria and alternatives.

We normalize the decision matrix using Eq. (1) as shown in Table 7.

Then we compute the entropy value using Eq. (2).

Then we compute the criteria weights using Eq. (4).

Table 7. Normalized values by Entropy method.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9

A_1	0.098649	0.078799	0.121052	0.108129	0.100532	0.105299	0.100216	0.101312	0.112754
A_2	0.078834	0.08917	0.065636	0.081256	0.11071	0.105033	0.096898	0.068121	0.084518
A_3	0.103362	0.093587	0.121052	0.108129	0.092389	0.093742	0.105062	0.09997	0.126682
A_4	0.102621	0.06896	0.089665	0.108403	0.05388	0.110227	0.072817	0.122512	0.112469
A_5	0.103362	0.116648	0.111998	0.091951	0.111291	0.083902	0.135109	0.117725	0.07753
A_6	0.088103	0.132337	0.085789	0.084623	0.120043	0.095829	0.100216	0.082828	0.084565
A_7	0.147201	0.105007	0.079581	0.072802	0.086144	0.100756	0.10169	0.114181	0.07753
A_8	0.093873	0.091903	0.082488	0.141018	0.128185	0.105181	0.084926	0.084716	0.112754
A_9	0.087567	0.118731	0.126215	0.122433	0.098288	0.091404	0.105062	0.088393	0.084518
A_{10}	0.096426	0.104859	0.116525	0.081256	0.098538	0.108628	0.098004	0.120242	0.126682

Then we compute the average solution using Eq. (5).

Then we compute the positive and negative distance from the average solution suing Eqs. (6-9) as shown in Table 8 and 9.

Then we compute the weighted PR and NR using Eqs. (10 and 11).

Then we compute the weighted normalized SPR and SNR using Eqs. (12 and 13).

Then we compute the appraisal score using Eq. (14).

Table 8. PR_{ij} values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0	0	0.21052	0.081287	0.005317	0.05299	0.002157	0.013117	0.127537
A_2	0	0	0	0	0.107095	0.050326	0	0	0
A_3	0.033624	0	0.21052	0.081287	0	0	0.05062	0	0.266816
A_4	0.026215	0	0	0.084029	0	0.102265	0	0.225115	0.124685
A_5	0.033624	0.166477	0.119977	0	0.112911	0	0.351089	0.17725	0
A_6	0	0.323366	0	0	0.200426	0	0.002157	0	0
A_7	0.472012	0.050066	0	0	0	0.007562	0.016901	0.141807	0
A_8	0	0	0	0.410182	0.281849	0.051806	0	0	0.127537
A_9	0	0.187307	0.262151	0.224331	0	0	0.05062	0	0
A_{10}	0	0.048588	0.165248	0	0	0.086284	0	0.202425	0.266816

Table 9. NR_{ij} values.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
A_1	0.013509	0.212008	0	0	0	0	0	0	0
A_2	0.211659	0.108301	0.343639	0.187435	0	0	0.031016	0.318792	0.154822
A_3	0	0.06413	0	0	0.076105	0.062579	0	0.000298	0
A_4	0	0.310396	0.103352	0	0.4612	0	0.271829	0	0
A_5	0	0	0	0.080495	0	0.160982	0	0	0.224699
A_6	0.118968	0	0.142113	0.153769	0	0.041714	0	0.171718	0.154347
A_7	0	0	0.204191	0.271982	0.138557	0	0	0	0.224699

A_8	0.061273	0.080971	0.17512	0	0	0	0.15074	0.152837	0
A_9	0.124328	0	0	0	0.017115	0.085959	0	0.116069	0.154822
A_{10}	0.035736	0	0	0.187435	0.014623	0	0.019958	0	0

Then we obtain the criteria weighs in three cases as shown in Table 10. We obtained the final ranks in Table 11.

Table 10. Criteria weights.

	First case	Second case	Third case
C_1	0.222	0.211	0.099
C_2	0.1029447	0.1470498	0.1191708
C_3	0.130798	0.124367	0.151414
C_4	0.122812	0.116774	0.14217
C_5	0.126572	0.120349	0.146523
C_6	0.020085	0.019098	0.023251
C_7	0.067835	0.0645	0.078528
C_8	0.097036	0.092265	0.112331
C_9	0.110178	0.104761	0.127544

Table 10. Final Ranks.

	First case	Second case	Third case	Final ranks
A_1	1	1	1	1
A_2	10	10	6	10
A_3	3	3	2	3
A_4	6	6	9	6
A_5	4	5	7	7
A_6	5	4	5	5
A_7	9	9	8	9
A_8	8	7	10	8
A_9	7	8	4	4
A_{10}	2	2	3	2

4. Conclusions

The evaluation of innovation and entrepreneurship education in higher vocational colleges is essential for ensuring that students are equipped with the necessary skills to navigate the complexities of modern business environments. This study highlights the importance of a multi-dimensional assessment framework, considering factors such as curriculum relevance, faculty expertise, industry collaboration, and technological integration. By employing MCDM methodologies, this research provides a structured and objective analysis of entrepreneurship programs, helping institutions identify areas for improvement and best practices. We use the

IndetermSoft set to deal with indeterminacy in criteria values. This study proposed three cases to compute the criteria weights by Entropy and ranking the alternatives by EDAS method.

Findings suggest that vocational colleges with strong industry linkages, hands-on training opportunities, and up-to-date curricula perform better in preparing students for entrepreneurial success. The study underscores the need for institutions to foster dynamic learning environments where students can engage with real-world business challenges, participate in startup incubators, and leverage digital tools for innovation. Additionally, continuous faculty development and investment in modern educational infrastructure are necessary to enhance the overall effectiveness of entrepreneurship education.

5. Study Implications

By implementing the proposed evaluation framework, policymakers, educators, and industry stakeholders can make informed decisions to improve the quality of entrepreneurship education in vocational institutions. Strengthening partnerships between academia and industry, integrating digital resources, and fostering experiential learning will ensure that students graduate with the skills, knowledge, and confidence required to succeed in the entrepreneurial landscape. The development of high-quality entrepreneurship education programs in vocational colleges is crucial for promoting innovation-driven economic growth. By continuously refining evaluation models and aligning educational strategies with industry trends, vocational institutions can produce a workforce that is not only employable but also capable of driving business innovation and creating sustainable economic opportunities

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