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An Empirical Study on the Quality of Industry-Linked Education in Vocational Colleges: Double-Framed TreeSoft Set Framework

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Abstract: Integrating industry-linked education into vocational college courses has been a key tactic for improving workforce preparedness in recent years. This study examines the extent and efficacy of industrial cooperation in vocational education contexts, emphasizing the effects of such alliances on innovation, employability, and skill acquisition. The study identifies obstacles that must be overcome and emphasizes important elements that lead to effective integration through empirical investigation. This study uses the multi-criteria decision making (MCDM) to deal with criteria and alternatives. The MAIRCA method is used to rank the alternatives. We use the Double-Framed TreeSoft Set to divide the main criteria into a tree. The findings are intended to provide useful information to industry partners, educators, and legislators who are trying to improve the caliber of vocational education.

Keywords: Double-Framed TreeSoft Set; Quality of Industry; Quality of Education; Vocational Colleges.

1. Introduction

In the past, vocational education has been essential in bridging the gap between academic education and the demands of the job market. Technology breakthroughs have caused the global economy to change quickly, which has increased the need for vocational training to better match business demands. Because of this congruence, graduates are guaranteed to have applicable, useful abilities that they can use right away in real-world situations[1], [2].

Through internships, cooperative education initiatives, and industry-driven projects, students at vocational institutions interact directly with companies through industry-linked education, which is acknowledged as a transformational strategy. These programs foster soft skills like communication, collaboration, and flexibility in addition to technical competence, all of which are critical for succeeding in the fast-paced industries of today.

The quality of industry-linked education implementation varies greatly throughout universities, despite its acknowledged significance. While some universities suffer with a lack of business relationships or antiquated training approaches, others have effectively incorporated experiential education into their programs. This discrepancy emphasizes the necessity of empirical research that methodically evaluates the efficacy of these kinds of partnerships[3], [4].

This study aims to assess the quality of industry-linked education from several angles, such as graduate employability, student happiness, faculty involvement with industry, and curricular relevance. It looks at how successfully vocational schools integrate real-world business practices into their instruction and how these practices affect the education results of their students[5], [6].

Keeping up mutually beneficial and long-lasting relationships between industry and vocational colleges is one of the primary issues noted. While universities must strike a balance between these demands and more general educational objectives, industries are frequently focused with short-term skill shortages. Designing successful, long-lasting partnerships requires an understanding of this equilibrium[7], [8].

This study's empirical methodology includes both quantitative and qualitative techniques, such as faculty interviews, student surveys, and input from industry partners. This multi-stakeholder viewpoint illuminates areas that require development and offers a comprehensive assessment of the condition of industry-linked education today[9].

According to preliminary research, there are still gaps in areas like curriculum innovation, regular industry engagement, and student competency evaluation, even though many vocational institutions have made great progress in incorporating industry collaborations. It will take both deliberate actions and continuous evaluation systems to close these gaps.

Finally, by providing evidence-based suggestions, this study hopes to add to the larger conversation on vocational education reform. In addition to improving individual career possibilities, raising the standard of industry-linked education would make the workforce more competitive and adaptable overall in the face of swift advancements in technology and the economy[10], [11].

2. Double-Framed TreeSoft Set

Smarandache created new types of soft set[12], [13], [14]s. We show the operations of the Double-Framed TreeSoft Set (DFTSS). DFTSS can extend the concept of the TreeSoft set to divide the criteria into tree by two frames[15], [16].

Let U be a universal set, Tree(A) be a hierarchical citron tree constructed from a criterion set $A = \{A_1, A_2, A_3, A_4, A_5, A_6, \dots, A_n\}$. $P\big(Tree(A)\big)$ is the power set of all nodes in the Tree(A).

DFTSS is a triple can be defined as:

$$D_1, D_2; Tree(A) \tag{1}$$

$$D_1: P\big(Tree(A) \to P(U)\big) \tag{2}$$

$$D_2: P\big(Tree(A) \to P(U)\big)$$
(3)

$X \sqsubseteq Tree(A), D_1(X), D_2(X)$ introduces two frames positive and negative.

We show the steps of the MAIRCA. Let experts create the decision matrix by their operations. We combine their opinions into a single matrix.

Determine the criteria weights by the average method. The criteria weights effect on the decision-making ranking.

Compute the components $Q_{p_{ij}}$ of the theoretical rating matrix

$$Q_{p_{ij}} = x_{ij} * W_j \tag{4}$$

Where x_{ij} refers to the opinion of experts and decision makers.

Compute the real rating matrix

$$R_{ij} = Q_{p_{ij}} \left(\frac{x_{ij} - \min x_i}{\max x_i - \min x_i}\right) \tag{5}$$

$$R_{ij} = Q_{p_{ij}} \left(\frac{x_{ij} - \max x_i}{\min x_i - \max x_i}\right) \tag{6}$$

Compute the total gap matrix

$$G_{ij} = Q_{p_{ij}} - R_{ij} \tag{7}$$

Compute the value of each alternative.

$$V_i = \sum_{i=1}^{m} G_{ij} \tag{8}$$

Rank the alternatives.

3. Results and Discussion

This section shows the results of the proposed approach. We use four main criteria and ten alternatives. We divide four main criteria into a tree. In each brace we compute the criteria weights.

C1: Curriculum Alignment with Industry Needs

- C1.1: Industry-Relevant Course Content (High, Medium, Low)
    - C1.1.1: Updated syllabus → High
    - C1.1.2: Practical skill components → Medium
    - C1.1.3: Certification and licensing integration → High

- C1.2: Collaboration in Curriculum Design (Strong, Moderate, Weak)
  - C1.2.1: Industry advisory boards → Strong
  - C1.2.2: Joint curriculum reviews → Moderate
  - C1.2.3: Industry-led course modules → Strong
- C1.3: Technology and Equipment Matching Industry Standards (Excellent, Good, Fair)
  - C1.3.1: Access to latest equipment → Excellent
  - C1.3.2: Digital education tools → Good
  - C1.3.3: Simulation environments → Good

C2: Practical Training Opportunities

- C2.1: Internship and Apprenticeship Programs (Comprehensive, Adequate, Limited)
  - C2.1.1: Duration and intensity → Comprehensive
  - C2.1.2: Relevance to coursework → Adequate
  - C2.1.3: Supervision and feedback → Comprehensive
- C2.2: On-the-Job Training Modules (Structured, Semi-structured, Unstructured)
  - C2.2.1: Structured training phases → Structured
  - C2.2.2: Education objectives clarity → Structured
  - C2.2.3: Performance evaluation systems → Semi-structured
- C2.3: Participation in Real Industry Projects (Frequent, Occasional, Rare)
  - C2.3.1: Industry-sponsored case studies → Frequent
  - C2.3.2: Capstone project integration → Frequent
  - C2.3.3: Field visits and observations → Occasional

C3: Faculty-Industry Engagement

- C3.1: Faculty Internships in Industry (Regular, Occasional, Rare)
  - C3.1.1: Frequency of industry immersion → Regular
  - C3.1.2: Duration of placements → Regular
  - C3.1.3: Application of new knowledge to teaching → Regular
- C3.2: Joint Research and Development Projects (Active, Moderate, Minimal)

- C3.2.1: Industry-cofunded research → Active
- C3.2.2: Product development collaborations → Moderate
- C3.2.3: Publication and patents outcomes → Minimal

- C3.3: Professional Development through Industry Certifications (Extensive, Moderate, Limited)
  - C3.3.1: Number of certifications attained → Extensive
  - C3.3.2: Training workshops attended → Moderate
  - C3.3.3: Integration of certification topics into classes → Extensive

C4: Graduate Employment and Satisfaction

- C4.1: Employment Rate in Related Fields (High, Moderate, Low)
  - C4.1.1: Job placement ratio → High
  - C4.1.2: Time to first employment → Moderate
  - C4.1.3: Alignment with studied discipline → High
- C4.2: Employer Satisfaction with Graduates (Excellent, Good, Fair)
  - C4.2.1: Technical skill competence → Excellent
  - C4.2.2: Soft skills and communication → Good
  - C4.2.3: Adaptability to workplace dynamics → Good
- C4.3: Graduate Self-Assessment (Positive, Neutral, Negative)
  - C4.3.1: Satisfaction with training → Positive
  - C4.3.2: Career progression tracking → Positive
  - C4.3.3: Perceived skill gaps → Neutral

Three experts rate the criteria and alternatives. We combine the opinions of the experts into a single matrix. We compute the criteria weights by the average method such as: C1= 0.251891874,

C2= 0.229720641, C3= 0.281808625, C4= 0.23657886. In each branch, we compute the criteria weights.

In the first branch, we combine the decision matrix into a single matrix as shown in Fig 1. Then we show the criteria weights as shown in Fig 2.

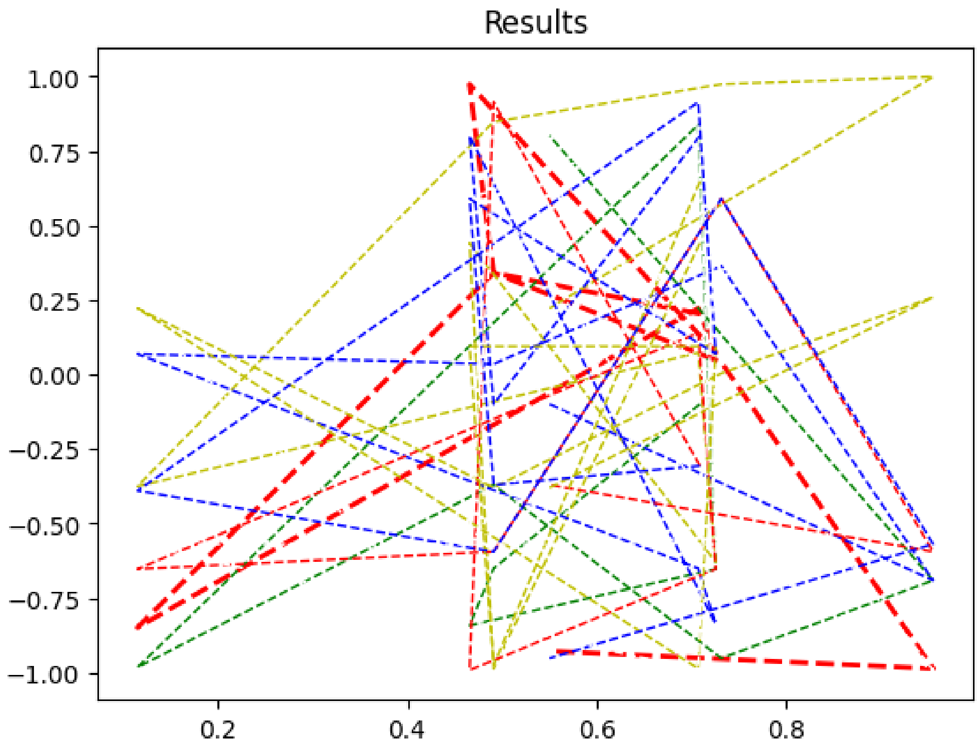

Figure 1. The combine decision matrix.

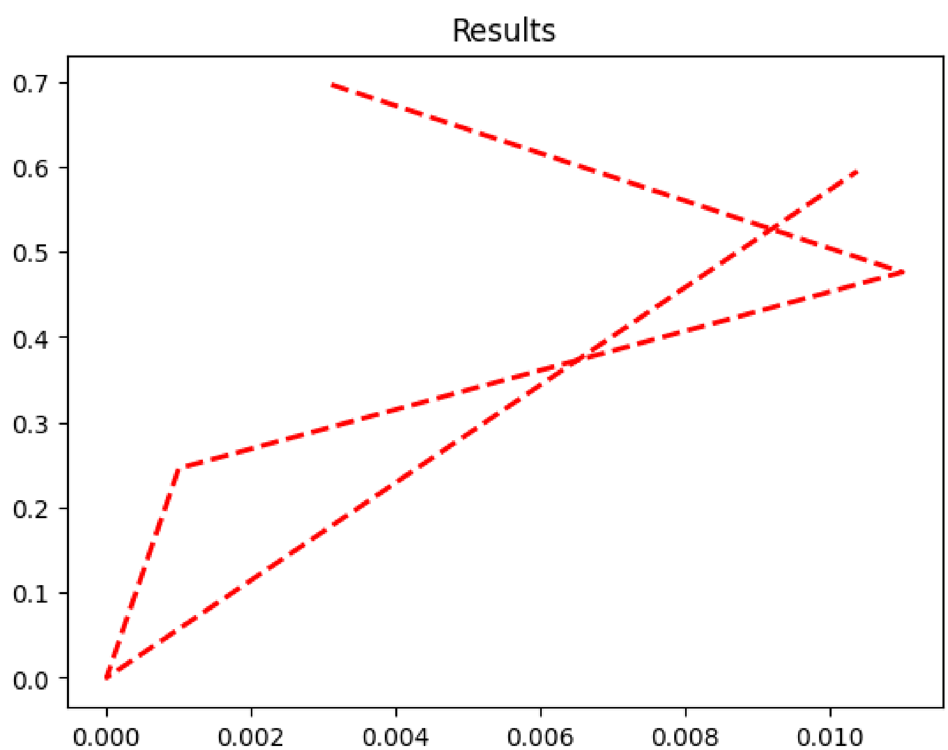

Figure 2. The criteria weights.

In the second branch, we combine the decision matrix into a single matrix as shown in Fig 3. Then we show the criteria weights as shown in Fig 4.

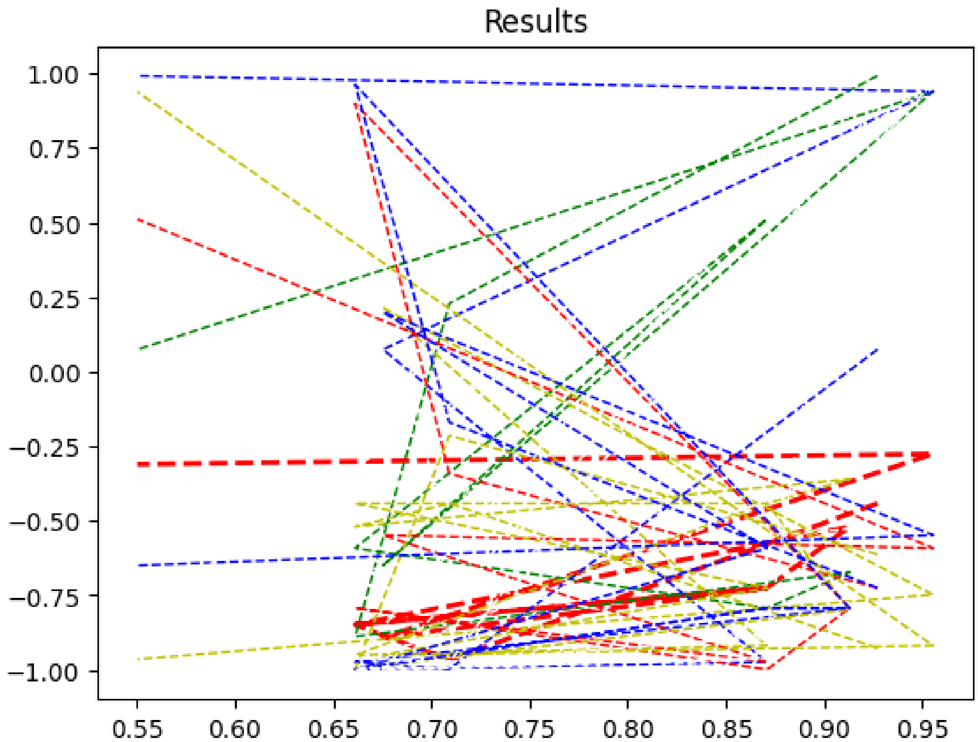

Figure 3. The combine decision matrix.

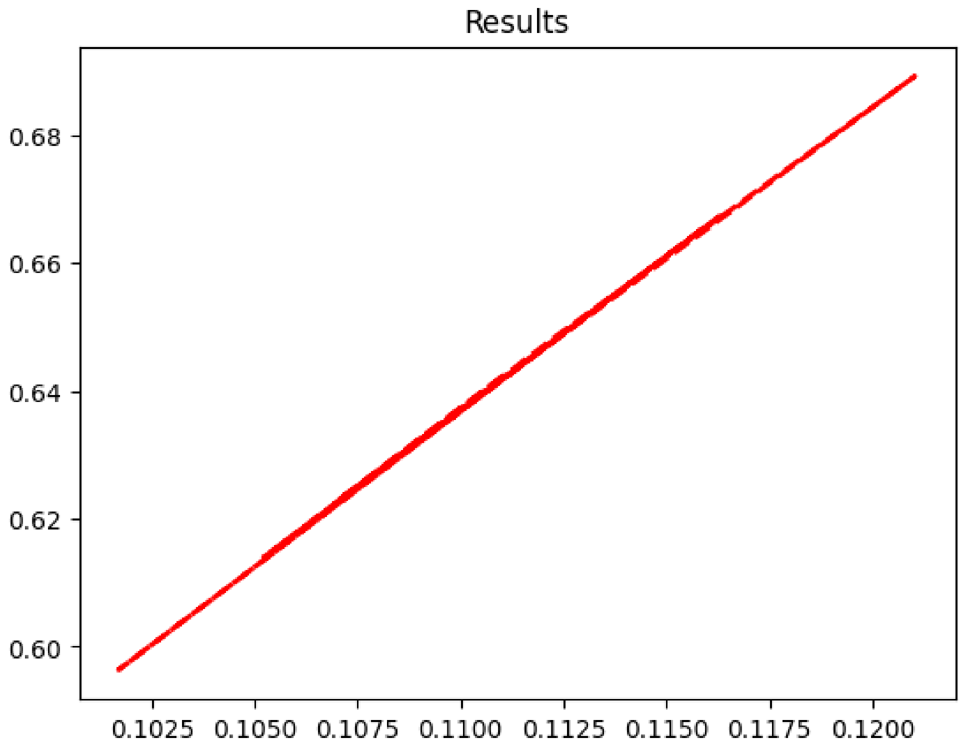

Figure 4. The criteria weights.

In the third branch, we combine the decision matrix into a single matrix as shown in Fig 5. Then we show the criteria weights as shown in Fig 6.

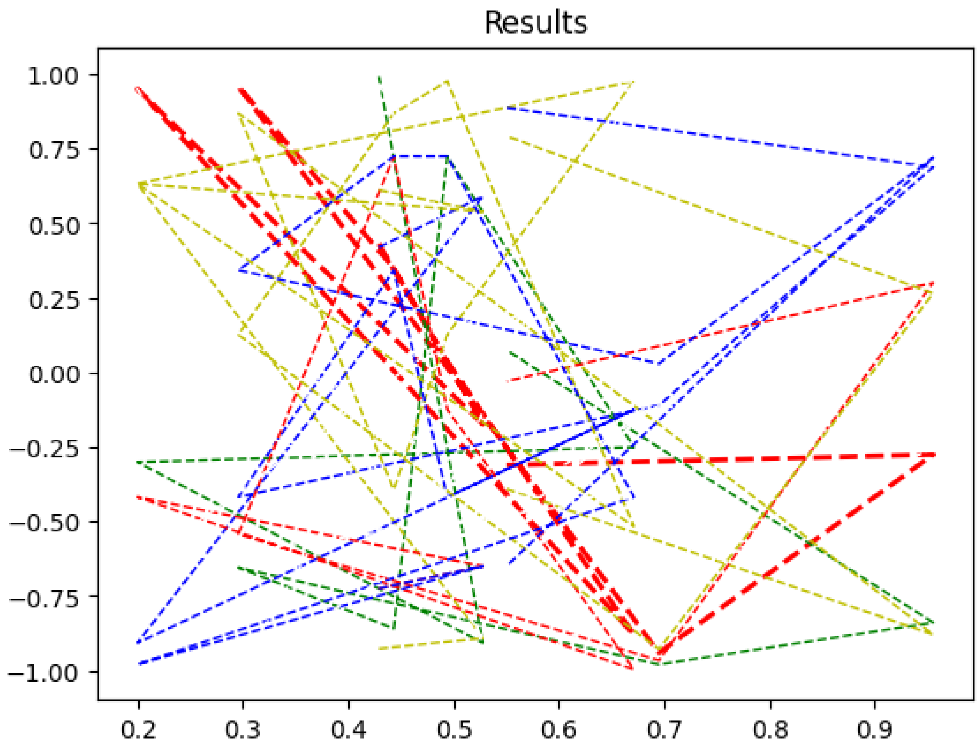

Figure 5. The combine decision matrix.

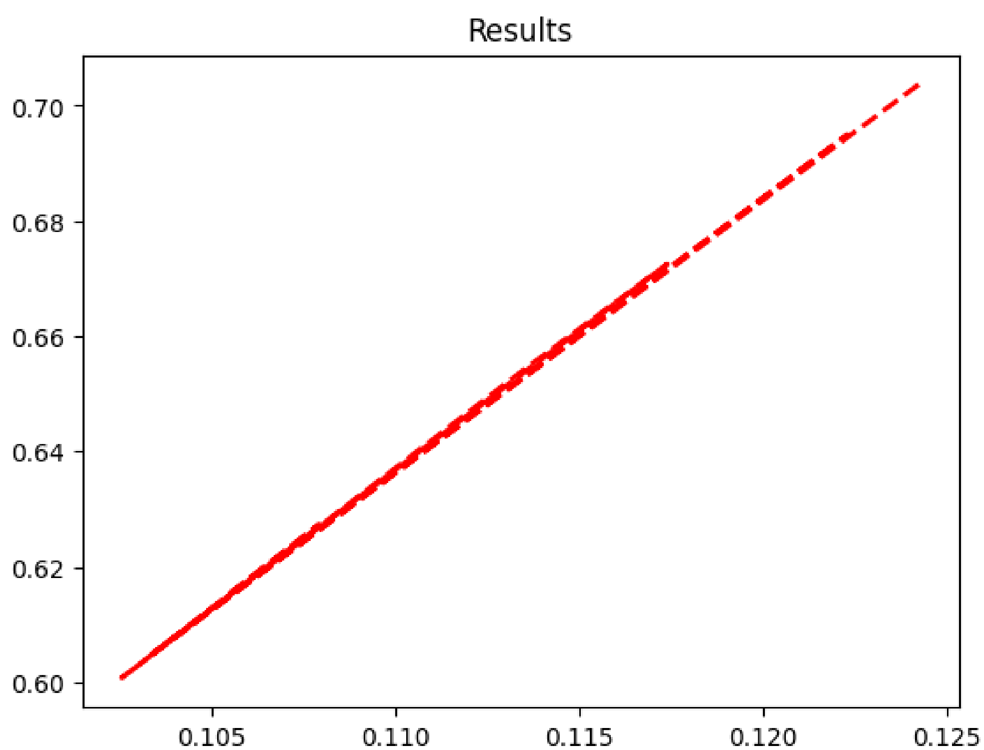

Figure 6. The criteria weights.

In the fourth branch, we combine the decision matrix into a single matrix as shown in Fig 7. Then we show the criteria weights as shown in Fig 8.

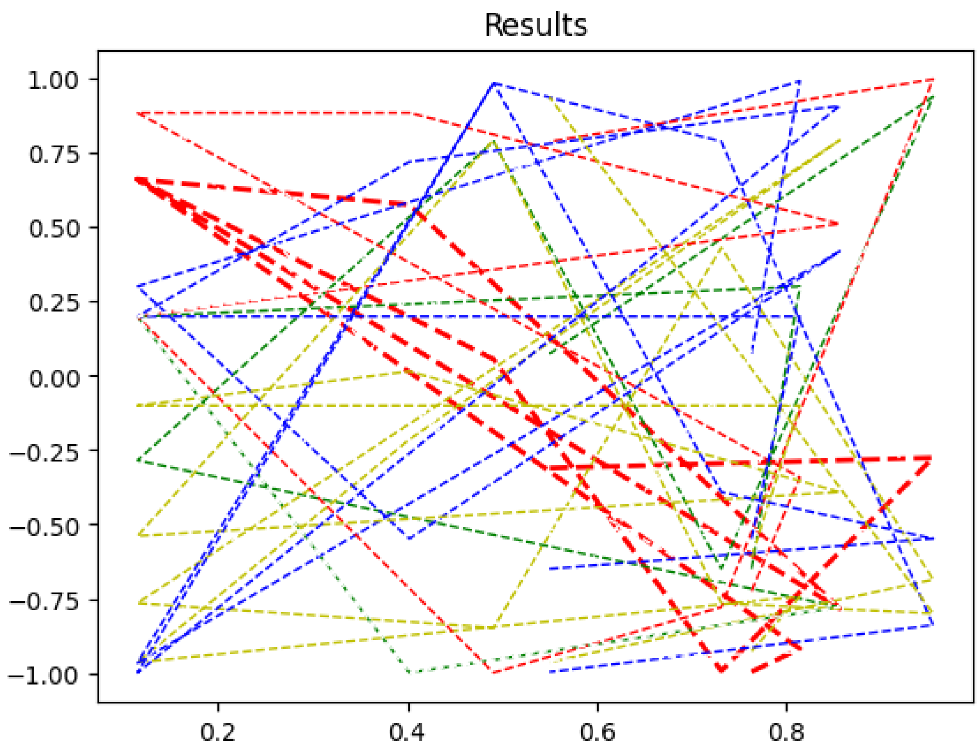

Figure 7. The combine decision matrix.

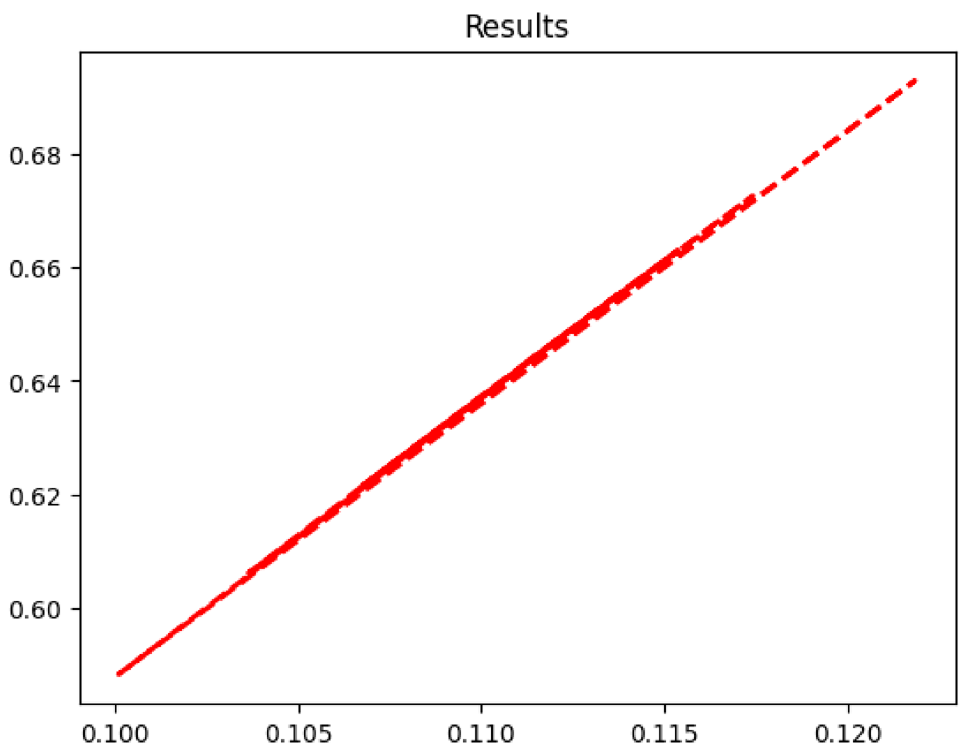

Figure 8. The criteria weights.

We obtain the global criteria weights such as:

- C1-1-1 0.0271 → Moderately important, ensuring course content is regularly refreshed.
- C1-1-2: 0.0247 → Slightly lower importance, but still essential for hands-on training.
- C1-1-3: 0.0303 → High importance, indicating strong emphasis on industry-recognized qualifications.
- C1-2-1: 0.0254 → Moderate value, showing engagement with industry in course design.
- C1-2-2: 0.0288 → Higher weight, stressing the need for continuous industry feedback.
- C1-2-3 0.0305 → Very important, highlighting industry professionals directly influencing education.
- C1-3-1: 0.0271 → Moderately high priority for keeping technical training up to date.
- C1-3-2 0.0292 → Important for integrating technology into education.
- C1-3-3: 0.0288 → Reflects a significant focus on realistic education experiences.
- C2-1-1: 0.0266 → Valuable for ensuring deep, meaningful work experience.

- C2-1-2: 0.0234 → Slightly less important but necessary to tie internships to studies.
- C2-1-3: 0.0267 → Moderate, emphasizing structured mentoring during internships.
- C2-2-1: 0.0242 → Important for guiding students during fieldwork.
- C2-2-2: 0.0258 → Moderately necessary for effective on-the-job training.
- C2-2-3: 0.0278 → High priority to track student education outcomes.
- C2-3-1: 0.0246 → Moderate focus, linking real-world problems to education.
- C2-3-2: 0.0252 → Necessary for deepening applied education.
- C2-3-3: 0.0255 → Helpful but a bit lower in emphasis compared to core projects.
- C3-1-1: 0.0350 → Highest among all, extremely crucial for upskilling faculty.
- C3-1-2: 0.0291 → Important but slightly less so than frequency.
- C3-1-3: 0.0345 → Very significant, ensuring fresh industry practices are taught.
- C3-2-1: 0.0289 → Important for promoting innovation through research.
- C3-2-2: 0.0319 → Fairly high importance, supporting active industry-driven R&D.
- C3-2-3: 0.0331 → Highly important, rewarding practical research achievements.
- C3-3-1: 0.0291 → Valuable, reflects ongoing faculty competence.
- C3-3-2: 0.0304 → Important to continually refresh skills.
- C3-3-3: 0.0297 → High value, making courses more career-relevant.
- C4-1-1: 0.0269 → Important for evaluating the success of education programs.
- C4-1-2: 0.0237 → Somewhat important, faster employment reflects better preparation.
- C4-1-3: 0.0288 → Strongly emphasized, linking training directly to careers.
- C4-2-1: 0.0245 → Needed to measure whether practical skills match jobs.
- C4-2-2: 0.0260 → Slightly higher focus on critical non-technical capabilities.
- C4-2-3: 0.0278 → Strong focus on graduates adjusting to real-world conditions.
- C4-3-1: 0.0253 → Important, relates to self-perceived readiness.
- C4-3-2: 0.0273 → Moderately high, showing long-term effectiveness.
- C4-3-3: 0.0263 → Valuable to identify areas for improvement.

We rank alternatives based on the criteria weights. We use DFTSS to split the alternatives into two frames such as:

D_1: $\{A_1, A_2, A_3, A_4, A_5\}$

D_1: $\{A_6, A_7, A_8, A_9, A_{10}\}$

In the first frame,

Compute the components $Q_{p_{ij}}$ of the theoretical rating matrix using eq. (4) as shown in Figure 9. Compute the real rating matrix using eq. (5 and 6) as shown in Figure 10. Compute the total gap matrix using eq. (7) as shown in Figure 11. Compute the value of each alternative using eq. (8) as Rank the alternatives as shown in Fig 12.

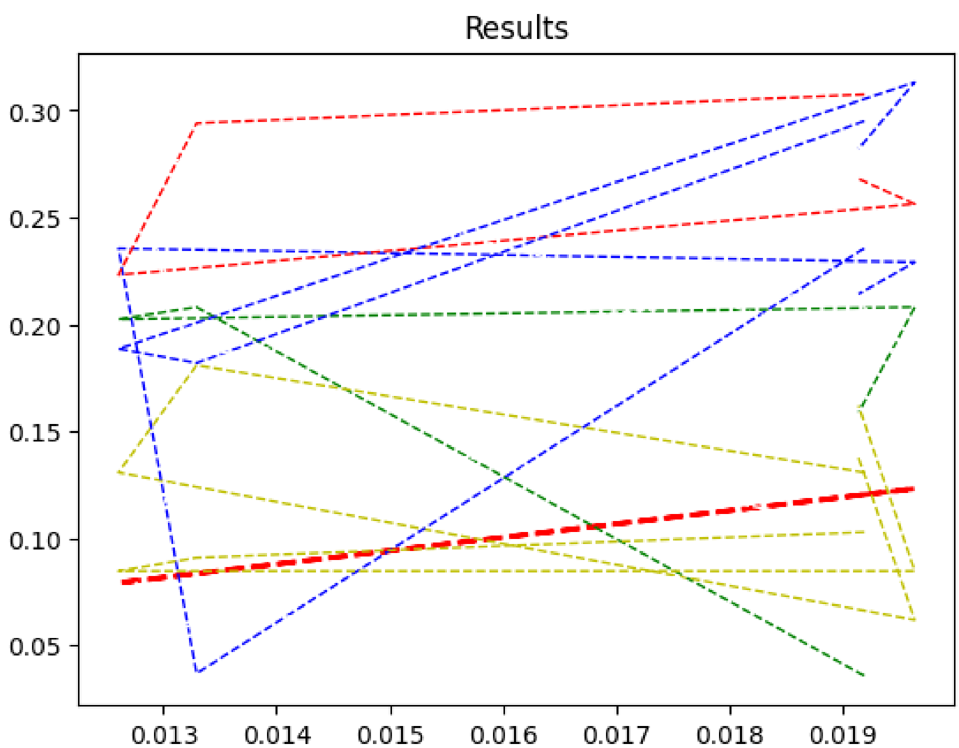

Fig 9. The theoretical rating matrix.

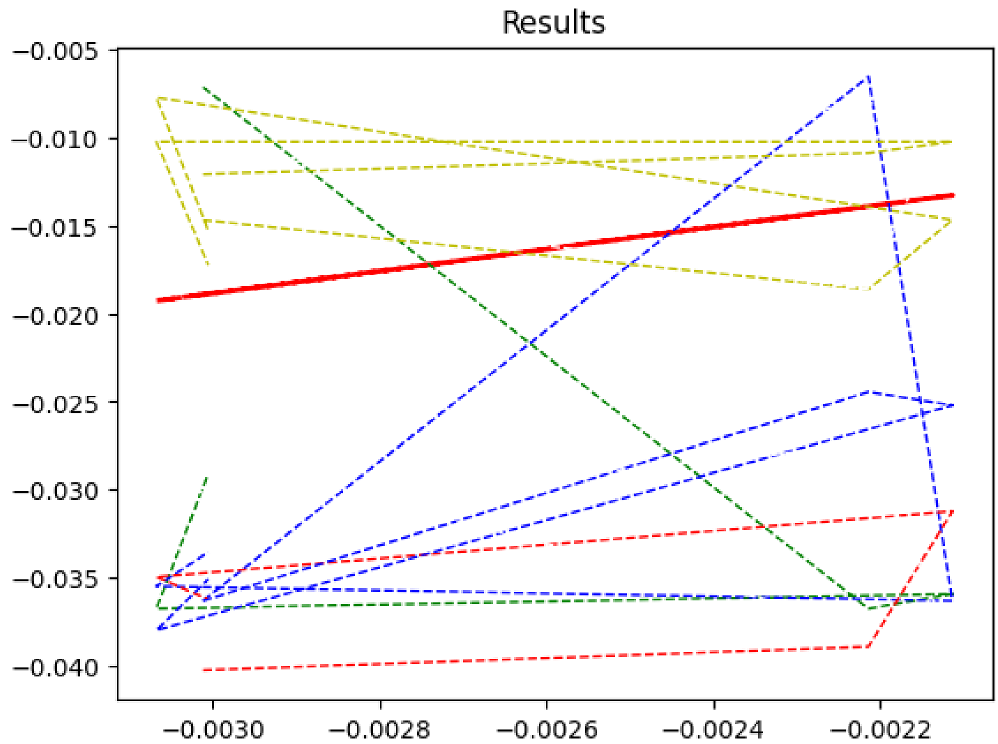

Fig 10. The rating matrix.

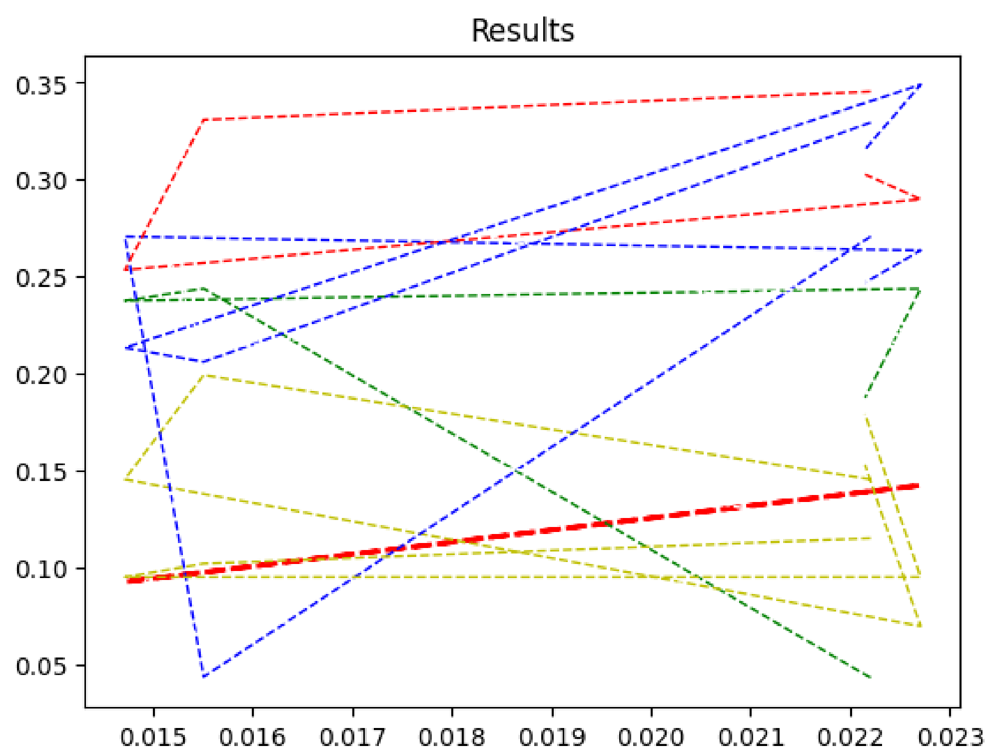

Fig 11. The total gap matrix.

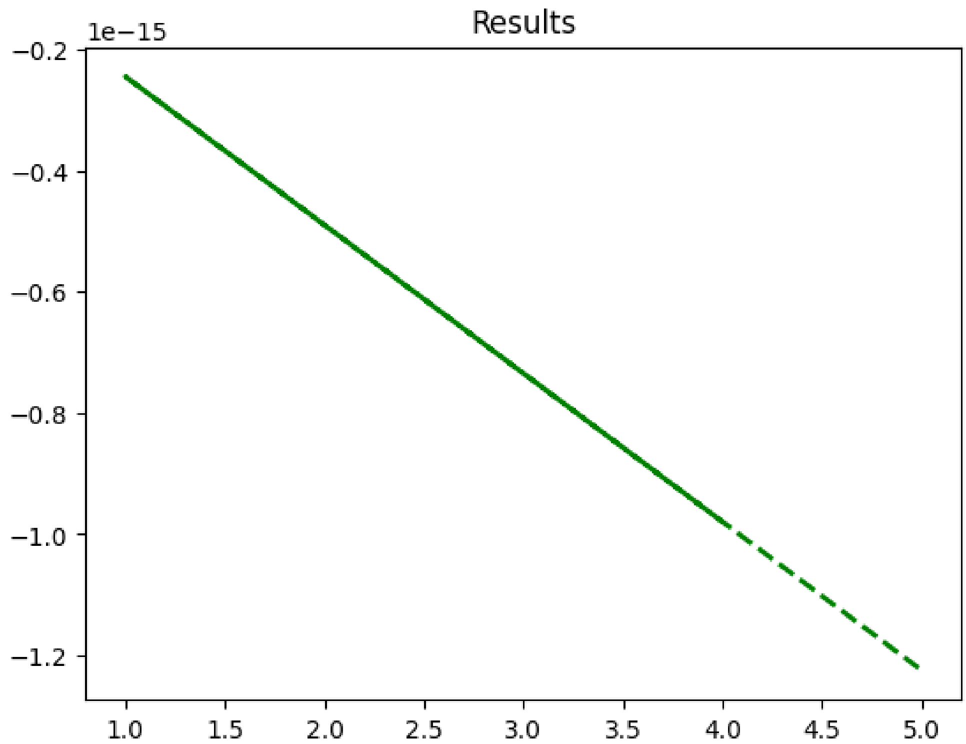

Fig 12. The ranks of alternative.

In the second frame,

Compute the components $Q_{p_{ij}}$ of the theoretical rating matrix using eq. (4) as shown in Figure 13. Compute the real rating matrix using eq. (5 and 6) as shown in Figure 14. Compute the total gap matrix using eq. (7) as shown in Figure 15. Compute the value of each alternative using eq. (8) as Rank the alternatives as shown in Fig 16.

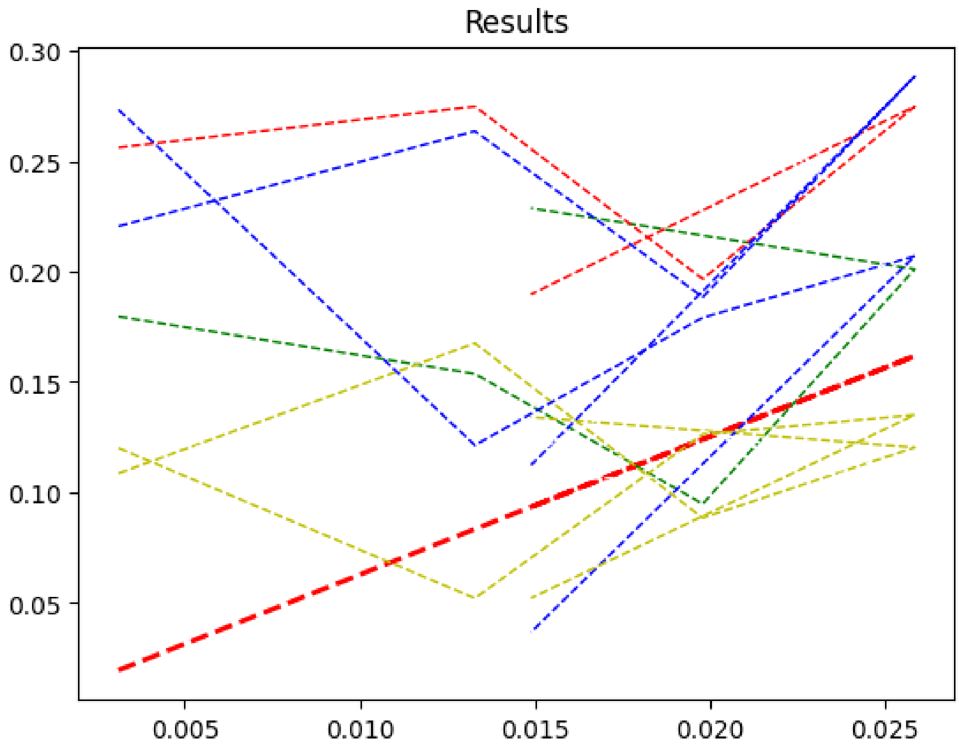

Fig 3. The theoretical rating matrix.

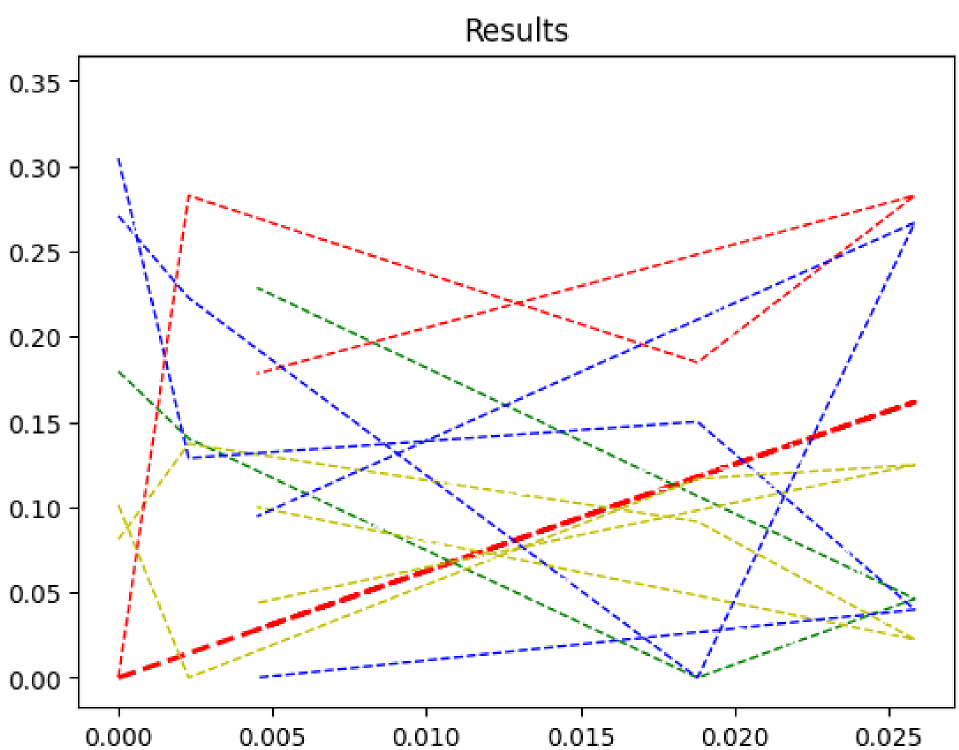

Fig 14. The rating matrix.

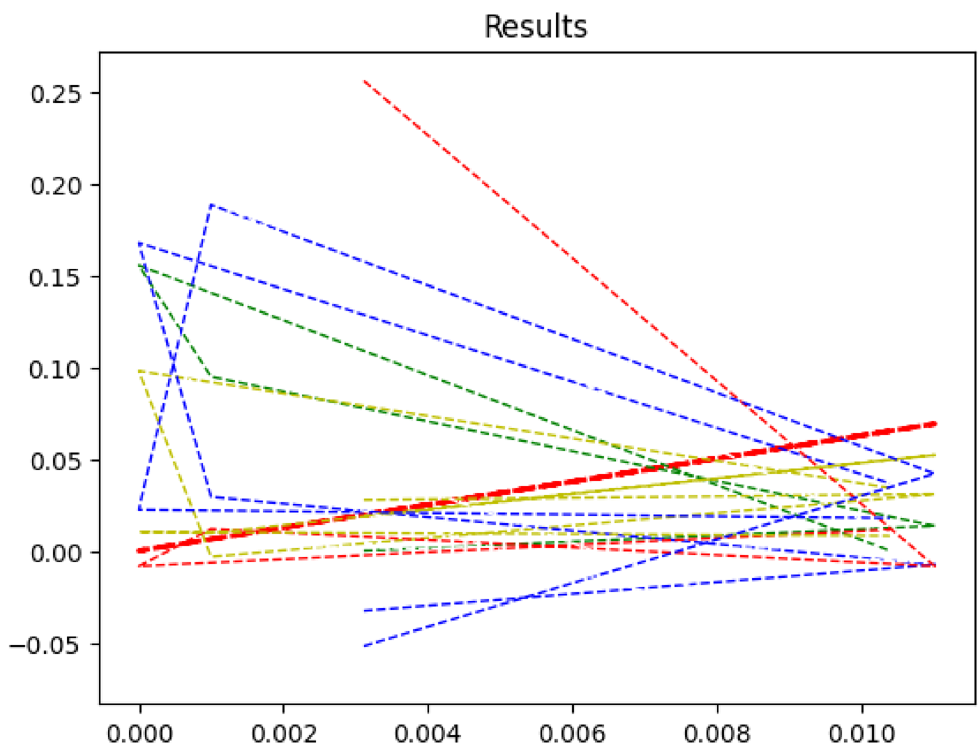

Fig 15. The total gap matrix.

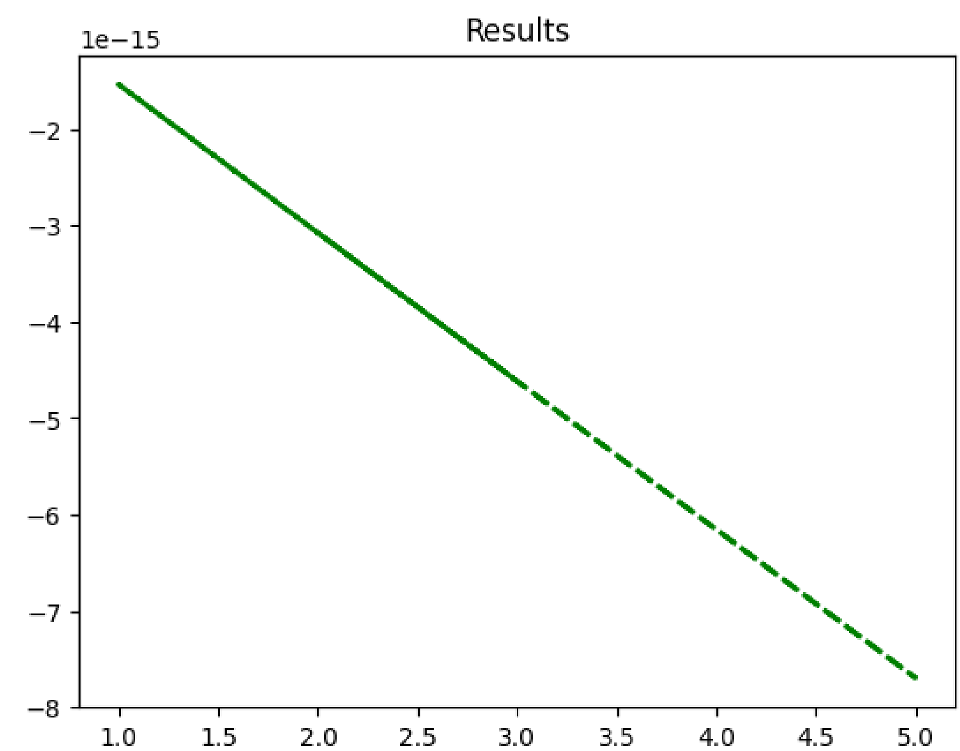

Fig 16. The ranks of alternative.

4. Conclusions

To adequately prepare students for the demands of contemporary companies, vocational institutions must provide high-quality industry-linked education. This empirical study emphasizes how companies and educational institutions must work together more closely to develop education experiences that are more dynamic, powerful, and relevant. Vocational colleges may enhance their strategies and produce more competent graduates and pleased industry partners by recognizing their strengths and areas for development. Double Framed TreeSoft Set is used in this study to divide alternatives to lower and higher. We use four main criteria and ten alternatives. In each main criterion, we compute the criteria weights and obtain the global weights. As industries change, future studies should keep an eye on these partnerships to make sure vocational education is adaptable, creative, and successful.

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