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Toward Better Physical Education Outcomes Assessing the Effectiveness of Blended Learning in Middle School Physical Education using TreeSoft Set

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Abstract: Physical education (PE) teaching methods have changed because of blended learning, which combines traditional in-person training with online learning resources. The implementation of blended learning in physical education in middle schools, when kids are going through major developmental changes, necessitates a thorough assessment to ascertain its actual efficacy. By looking at both technology integration and physical activity outcomes, this study investigates the critical elements that make blended learning in middle school physical education settings successful. The study assesses how environmental conditions, instructor involvement, student engagement, and instructional design affect overall learning effectiveness using a multi-criteria assessment approach. We use the TreeSoft set to divide the criteria and sub criteria as Tree and we compute the criteria weights in each local criteria and in global criteria. We rank the alternatives using the WSM method. For educators and policymakers looking to maximize physical education in a changing digital educational environment, the findings provide insightful information.

Keywords: TreeSoft Set; Blended Learning; Middle School; Physical Education; MCDM Problem.

1. Introduction

Globally, educational systems are undergoing fast change, and technology is becoming a more significant factor in determining how pupils learn. Physical education is one of the topics where blended learning, an instructional approach that combines traditional classroom experiences with online components, is becoming more and more popular. This change in pedagogy calls for a reevaluation of teaching methods, especially in middle school physical education, where active participation and physical growth are crucial[1], [2].

Physical education necessitates active engagement and skill development in physical activities, in contrast to academic topics that mostly rely on theoretical knowledge. Thus, there are special opportunities and problems associated with implementing blended learning in physical education. It challenges teachers to reconsider how digital resources can support or improve in-person instruction and the growth of students' fitness[3], [4].

A student's middle school years are a time of formative development, characterized by emotional, cognitive, and physical maturation. At this level, successful PE programs can promote healthy behaviors that last a lifetime. In this situation, blended learning strategies need to be thoroughly evaluated to make sure they support students' physical literacy while also meeting their developmental needs.

Blended physical education programs now frequently incorporate interactive apps, online fitness tracking, virtual evaluations, and video demonstrations. Although these tools offer flexibility and customization, it is yet unclear how well they will encourage participation and physical activity in the real world[5], [6]. To achieve the best results, it is imperative to investigate how these technologies are used in conjunction with in-person instruction.

Teachers in blended physical education settings frequently face challenges such inadequate technology infrastructure, a lack of training, and trouble remotely tracking students' progress[7], [8]. Understanding these issues and how they affect student outcomes and instructional quality is necessary for evaluating effectiveness.

Any physical education program's success depends heavily on the engagement and motivation of its students. Because of the combination of digital content and physical duties, it becomes more difficult to retain engagement in blended situations[9], [10]. As a result, one of the most important factors in determining how successful blended physical education programs are should be involvement.

To evaluate the efficacy of blended learning in middle school physical education, a strong framework with several assessment criteria is necessary. These could include learning environment, teacher support, student results, technological access, and instructional design. Stakeholders can determine areas for improvement as well as strengths through a multi-criteria review.

By looking at important success variables from both a qualitative and quantitative perspective, this study seeks to offer a thorough evaluation of blended learning in middle school physical education. It gives teachers and decision-makers a better idea of what makes blended learning effective in a topic that has historically relied on in-person interaction and presence.

Decision-makers (DMs) directly determine the relative weights of criteria in this procedure by weighing their relative importance. Either a group decision-making process or individual direct weighing can be used[11], [12]. Objective weighting techniques use various mathematical techniques to obtain the weights of criteria from the decision matrix. Among these, the significance of CRITIC and Shannon's entropy

In contrast to the previous category, several subjective weighting methods have been developed thus far to optimize the process of translating human thought into criteria weights. The primary basis of these methods is pairwise comparison, but there are other methods that use different approaches. Subjective weighting methods are more commonly used than objective weighting methods[13], [14]. They are primarily developed to translate DMs' opinions, expectations, assessments, judgments, and interpretations of the importance of criteria into weights for those criteria.

The HyperSoft Set (2018), IndetermSoft Set (2022), IndetermHyperSoft Set (2022), SuperHyperSoft Set, TreeSoft Set (2022), and ForestSoft Set (2024) are the six new varieties of Soft Sets that Smarandache announced[15], [16], [17], [18].

2. Proposed Model

A TreeSoft Set maps subsets of a universal set to the power set of Tree(A), a hierarchical tree-like structure of attributes. It is well known that MultiSoft Sets and comparable frameworks can be generalized using ideas like TreeSoft Sets[19], [20].

Let U be a universal set of discourse, and H non-empty set of U and the power set is P(U). Let set attributes or criteria or factors such as: $A = \{A_1, A_2, \dots, A_n\}; n \geq 1$, each attribute is considered a first-level attribute. Every first level attribute has different sub criteria

$$A_i = \{A_{i,1}, A_{i,2}, \dots\} \quad (1)$$

$$A_1 = \{A_{1,1}, A_{1,2}, \dots\} \quad (2)$$

$$A_2 = \{A_{2,1}, A_{2,2}, \dots\} \quad (3)$$

$$A_3 = \{A_{3,1}, A_{3,2}, \dots\} \quad (4)$$

$$A_4 = \{A_{4,1}, A_{4,2}, \dots\} \quad (5)$$

$$A_5 = \{A_{5,1}, A_{5,2}, \dots\} \quad (6)$$

$$A_6 = \{A_{6,1}, A_{6,2}, \dots\} \quad (7)$$

$$A_7 = \{A_{7,1}, A_{7,2}, \dots\} \quad (8)$$

$$A_8 = \{A_{8,1}, A_{8,2}, \dots\} \quad (9)$$

$$A_9 = \{A_{9,1}, A_{9,2}, \dots\} \quad (10)$$

$$A_{10} = \{A_{10,1}, A_{10,2}, \dots\} \quad (11)$$

The TreeSoft set is defined as:

$$F: P\big(Tree(A) \rightarrow P(H)\big) \quad (12)$$

We show an example of the TreeSoft Set as shown in Fig 1. In the first level, we show the six criteria, in the second level we show three criteria with values.

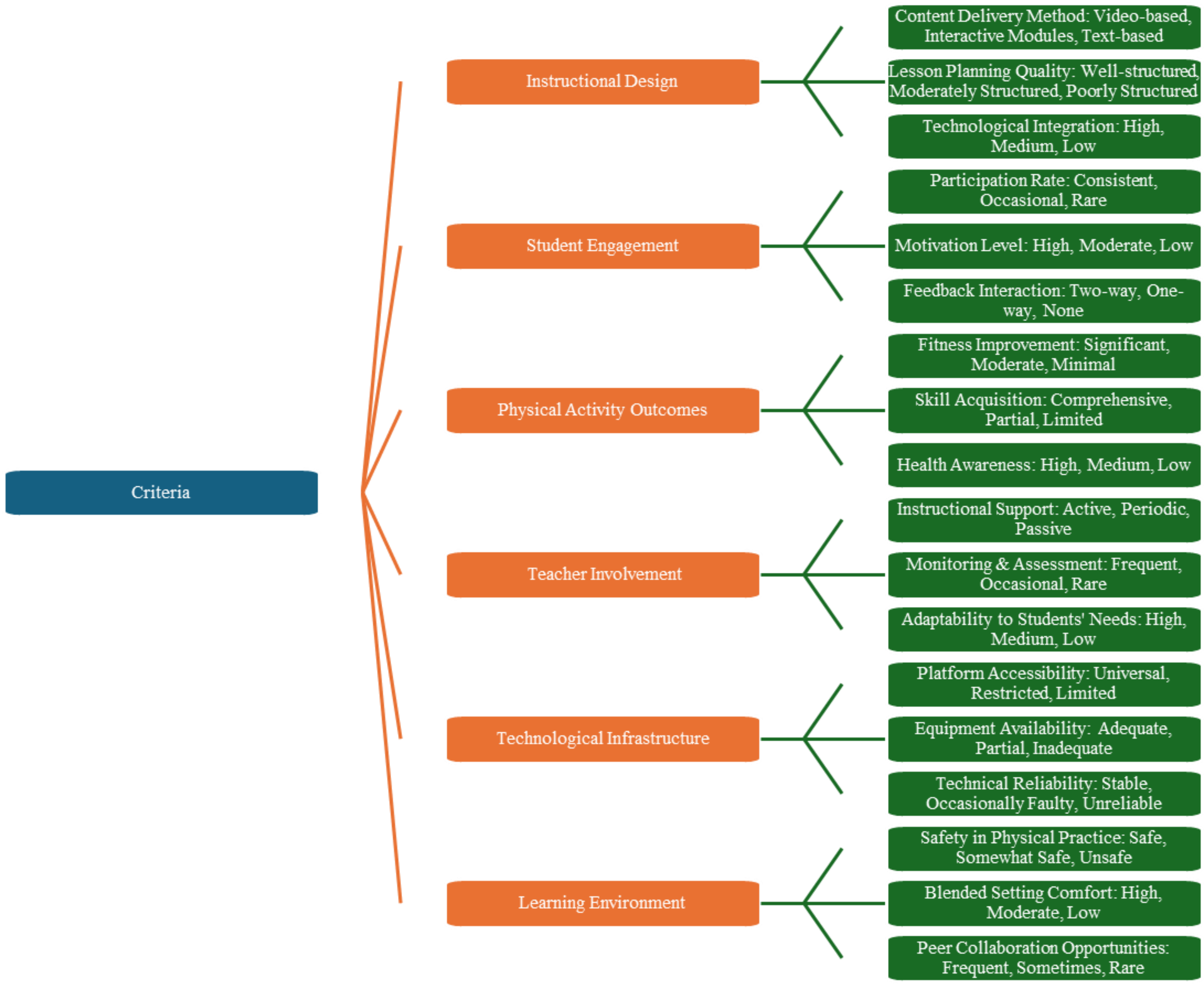

Fig 1. The TreeSoft graph.

We show the steps of the WSM method to rank the alternatives.

Create the decision matrix.

The decision makers create the decision matrix based on their opinions.

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{pmatrix} \tag{13}$$

Aggregate the decision matrix into a single matrix.

Compute the criteria weights.

The weights of the criteria are computed using the average method from the decision matrix between the criteria and the alternatives.

Compute the weighted decision matrix.

The weighted decision matrix is computed by multiplying the weights of criteria by the decision matrix.

$$H_{ij} = w_j x_{ij} \quad (14)$$

Compute the total sum of weighted decision matrix.

$$k_i = \sum_{i=1}^{n} H_{ij} \quad (15)$$

Rank the alternatives.

The alternatives are ranked based on the highest value on the k_i.

3. Application

We present an application of the proposed approach to computing the criteria weights and ranking alternatives. This study uses six criteria as shown in Fig 1. We use ten alternatives as: Flipped Classroom with Fitness Apps, Hybrid Weekly Online/Offline PE Sessions, Game-based Learning with Motion Sensors, Virtual Reality Assisted PE, Interactive Live-Streamed PE Lessons, Peer-Coached Blended Fitness Program, Pre-recorded Instruction with Daily Activity Logs, Project-Based Movement Challenges, Community Integrated Outdoor, AI-Personalized PE Instruction & Tracking.

We use the TreeSoft set to divide the criteria and sub criteria into a tree. We compute the weights of criteria in each level and then compute the global weights of criteria. In the first, we compute the weights of the main criteria. Three experts created the decision matrix between the main criteria and alternatives. We combine the decision matrix as shown in Fig 2. We compute the criteria weights using the average method.

C1– 0.1617, This criterion carries a moderate weight, highlighting the importance of how well the blended PE curriculum is structured, including the clarity of learning objectives, alignment with standards, and coherence in content delivery.

C2– 0.1652, With a slightly higher weight, student engagement is recognized as a critical factor in ensuring the success of blended PE. This includes motivation, participation, and active interaction with the platform and peers.

C3– 0.1803, This criterion holds the highest weight among all, reflecting the primary goal of physical education—improving students' fitness, physical skills, and health literacy. Its prominence emphasizes outcome-based success measurement.

C4– 0.1653, Teacher involvement is considered highly influential, almost equal to student engagement, emphasizing the role of instructors in delivering, adapting, and monitoring blended learning for maximum effectiveness.

C5– 0.1607, This factor is moderately significant, indicating that while technology is essential to enable blended learning, its impact is largely dependent on the quality of instruction and engagement strategies built around it.

C6– 0.1669, This weight suggests a substantial role of the physical and psychological environment where blended learning takes place. It encompasses factors like student comfort, safety, and opportunities for collaboration

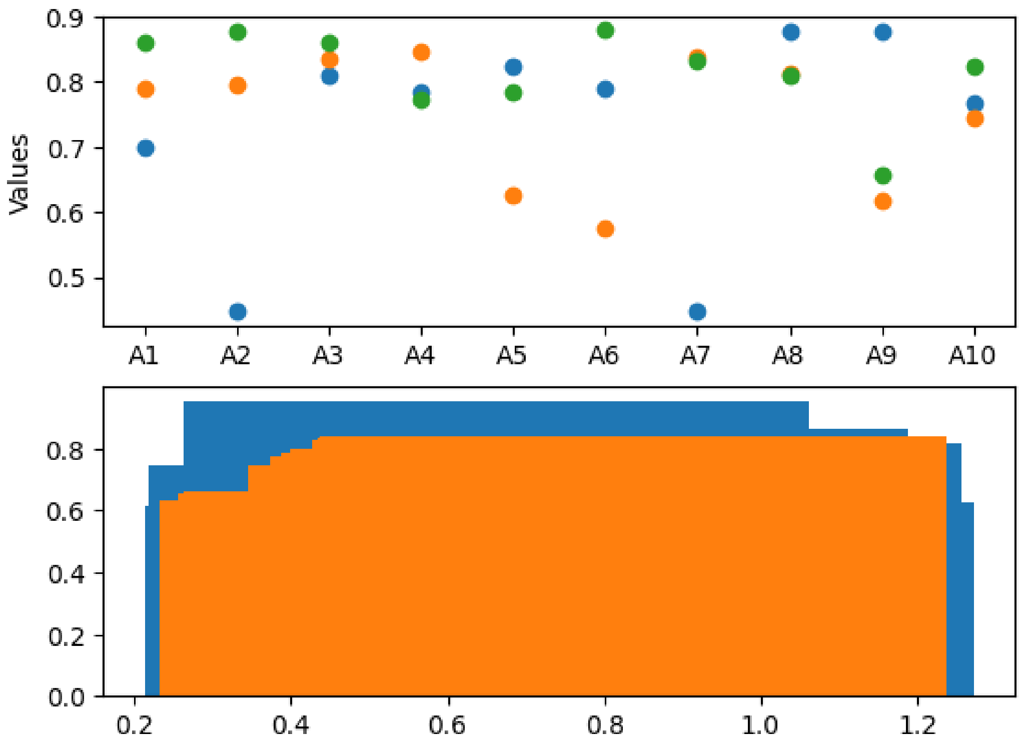

Fig 2. The combined decision matrix for main criteria.

Then we compute the criteria weights in the first sub criteria. We create the decision matrix between the criteria and alternatives. We combine the decision matrix as shown in Fig 3. We compute the criteria weights using the average method as shown in Fig 4.

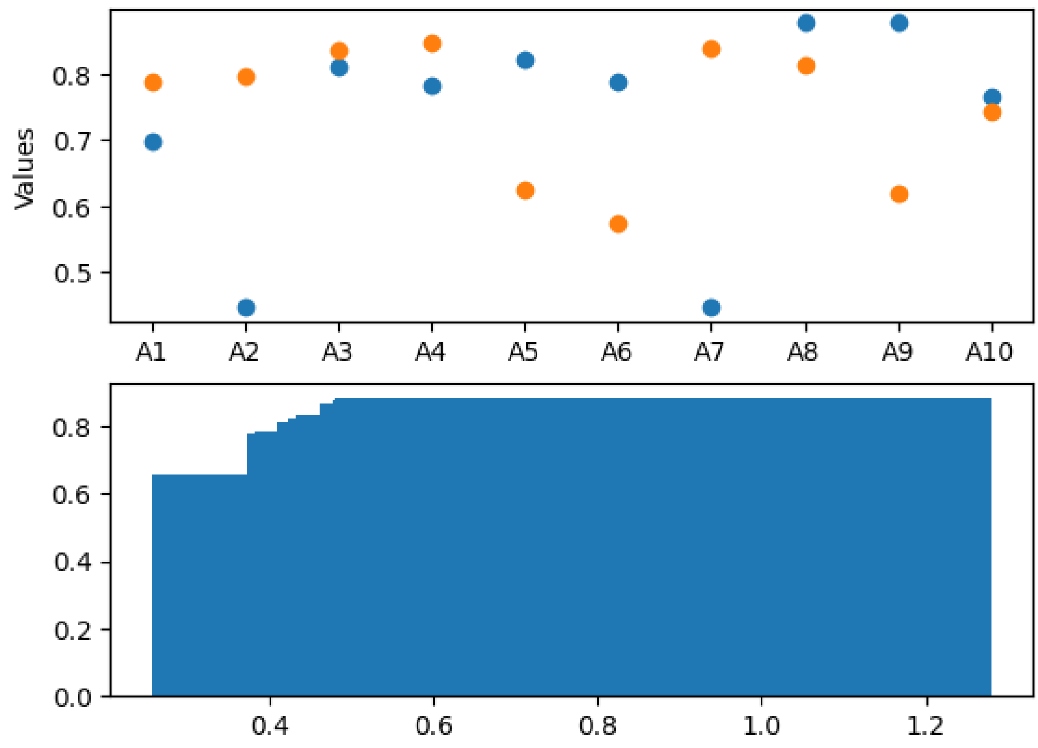

Fig 3. Combined decision matrix for first sub criterion.

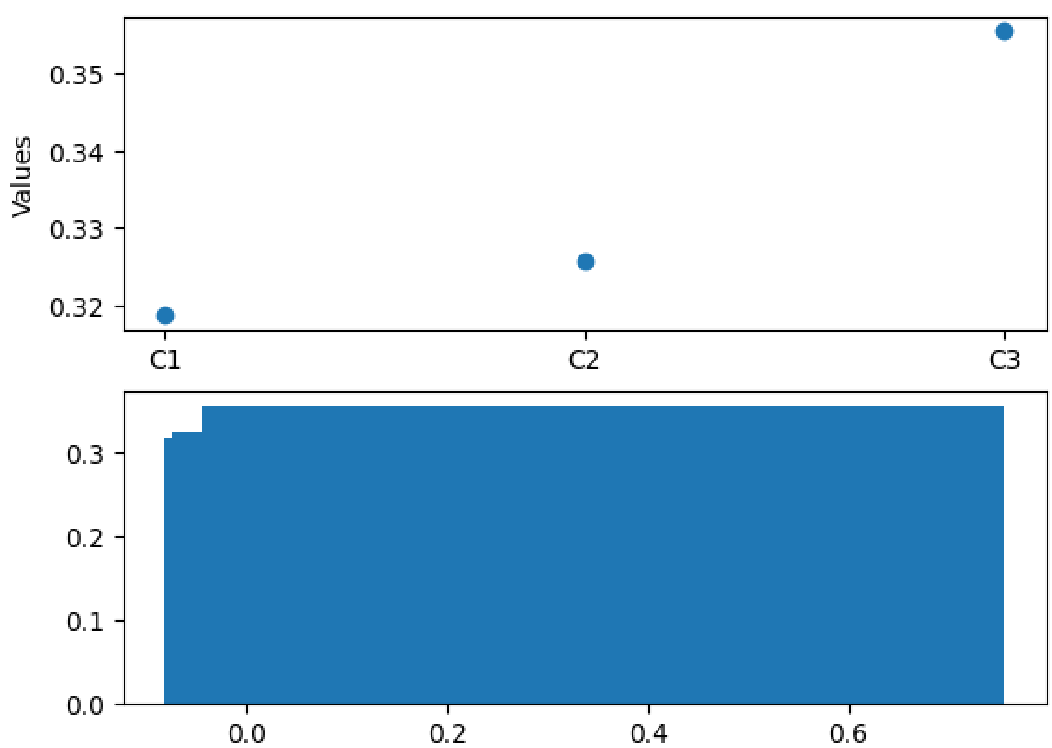

Fig 4. Weights of first sub criterion.

Then we compute the criteria weights in the second sub criteria. We create the decision matrix between the criteria and alternatives. We combine the decision matrix as shown in Fig 5. We compute the criteria weights using the average method as shown in Fig 6.

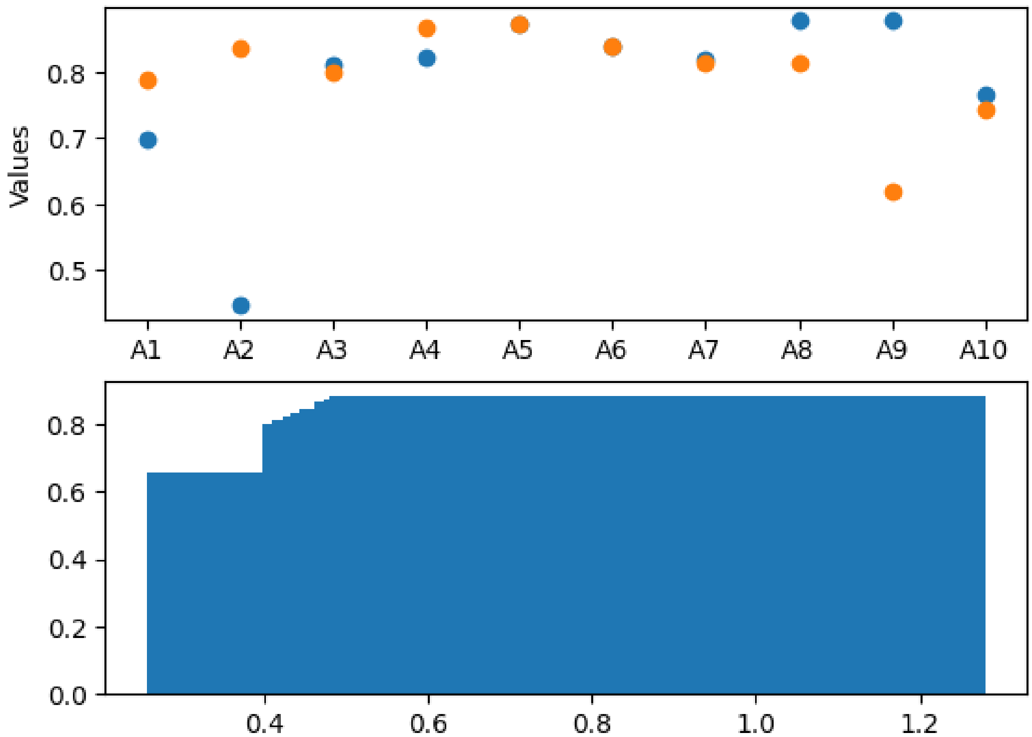

Fig 5. Combined decision matrix for second sub criterion.

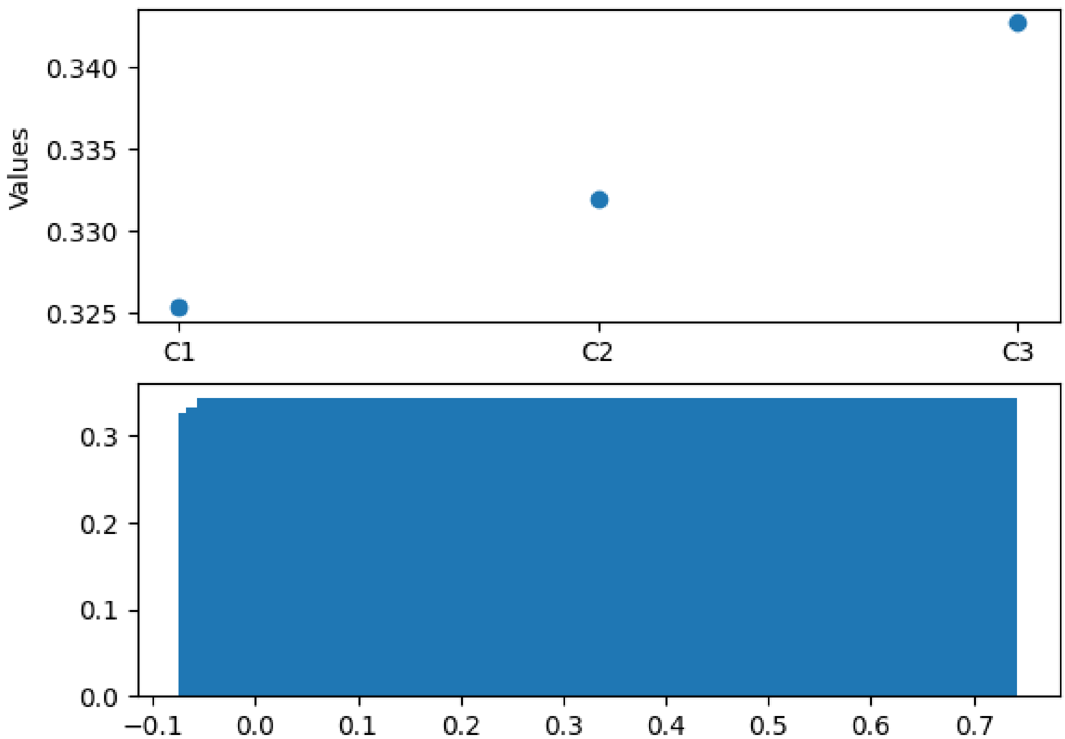

Fig 6. Weights of second sub criterion.

Then we compute the criteria weights in the third sub criteria. We create the decision matrix between the criteria and alternatives. We combine the decision matrix as shown in Fig 7. We compute the criteria weights using the average method as shown in Fig 8.

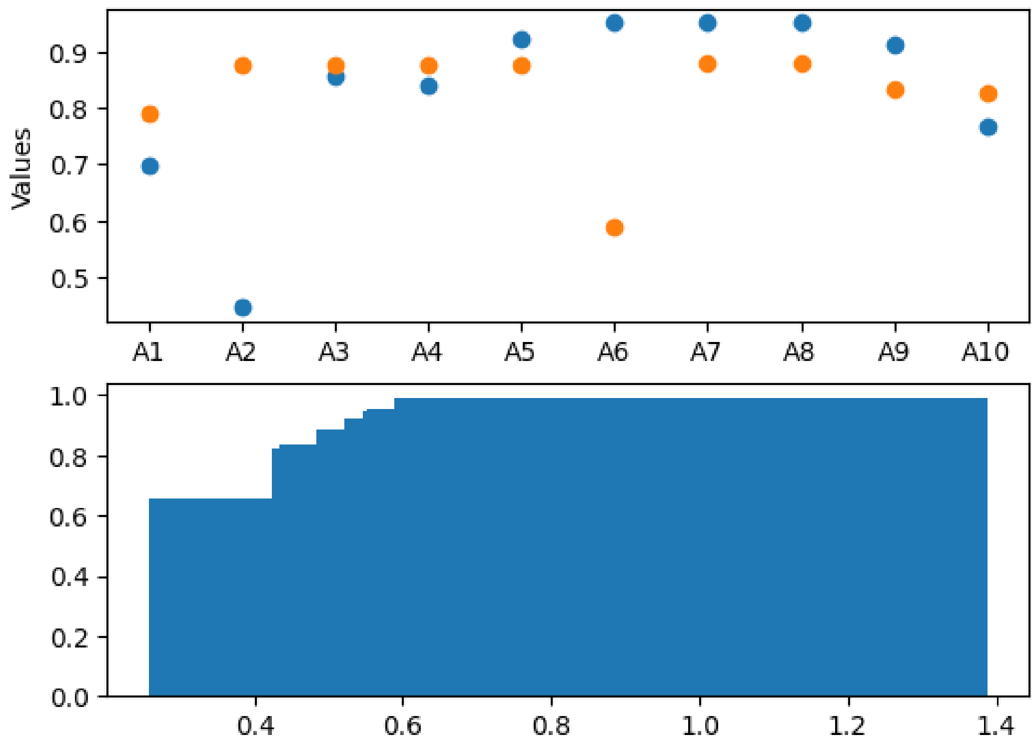

Fig 7. Combined decision matrix for third sub criterion.

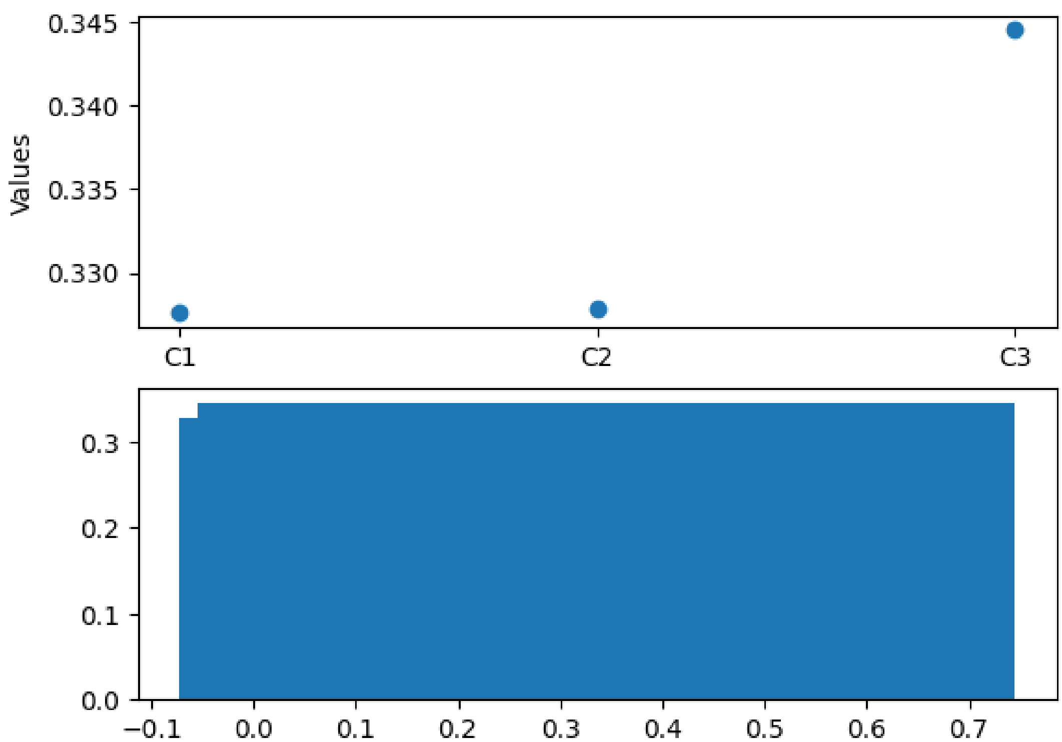

Fig 8. Weights of third sub criterion.

Then we compute the criteria weights in the fourth sub criteria. We create the decision matrix between the criteria and alternatives. We combine the decision matrix as shown in Fig 9. We compute the criteria weights using the average method as shown in Fig 10.

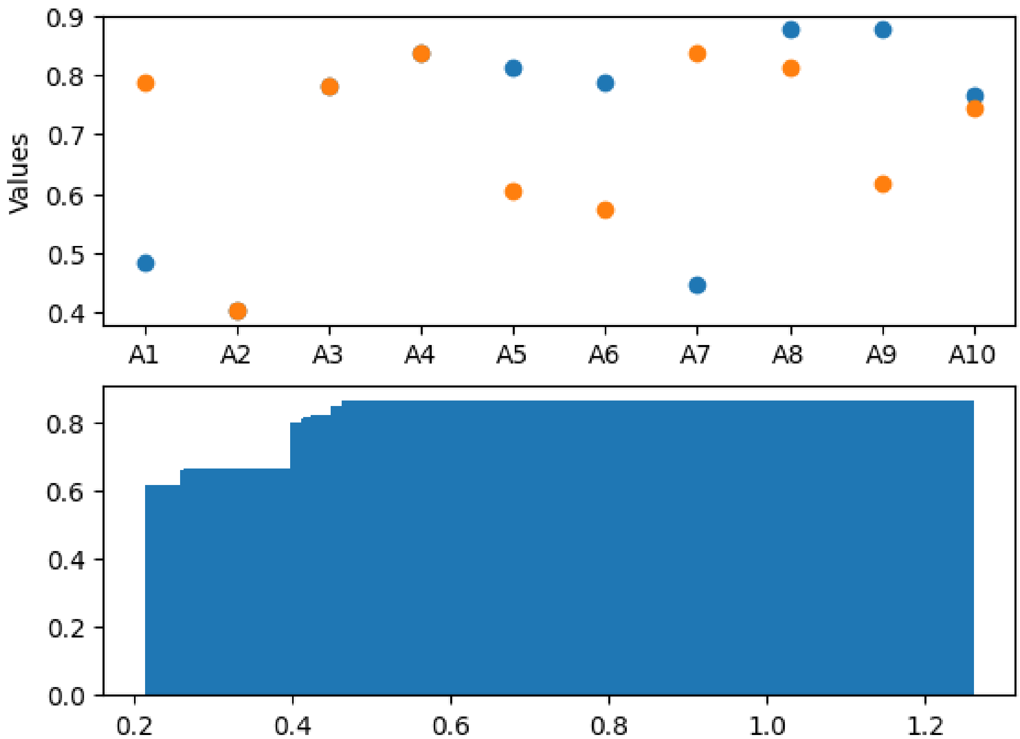

Fig 9. Combined decision matrix for fourth sub criterion.

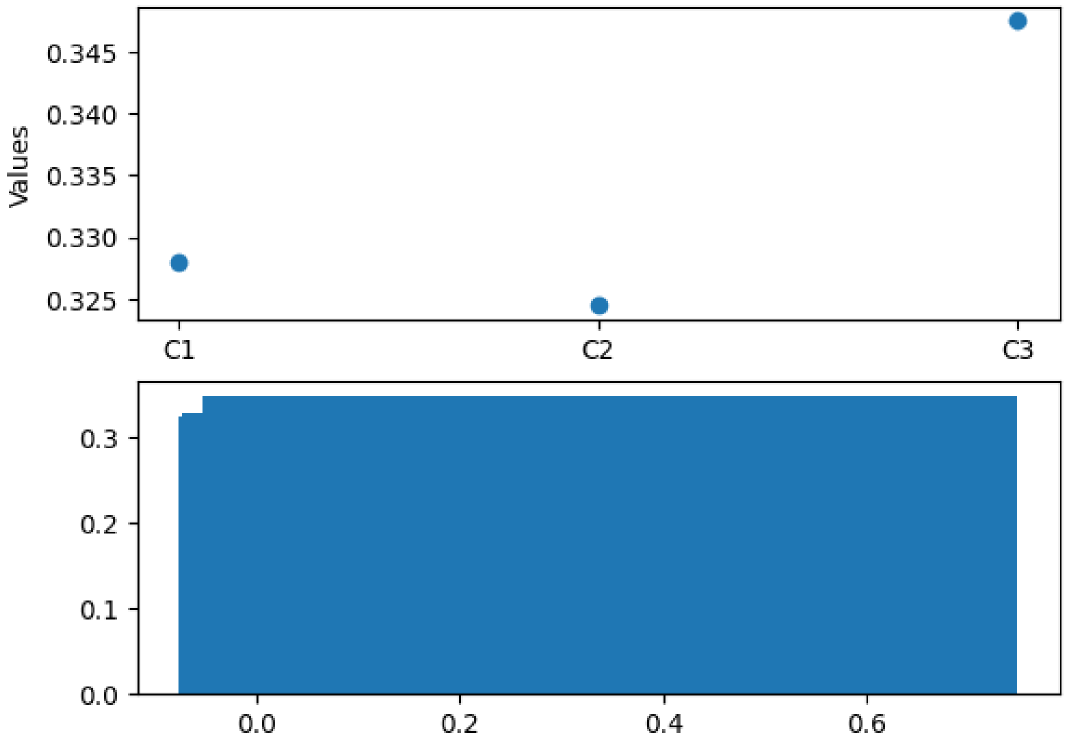

Fig 10. Weights of fourth sub criterion.

Then we compute the criteria weights in the fifth sub criteria. We create the decision matrix between the criteria and alternatives. We combine the decision matrix as shown in Fig 11. We compute the criteria weights using the average method as shown in Fig 12.

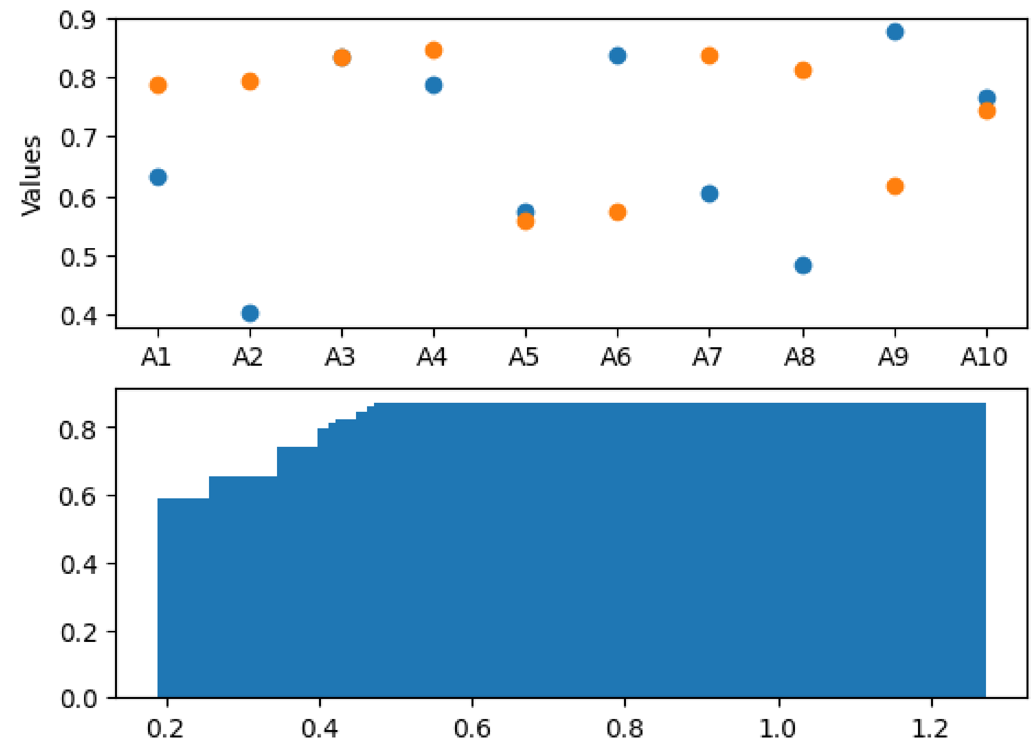

Fig 11. Combined decision matrix for fifth sub criterion.

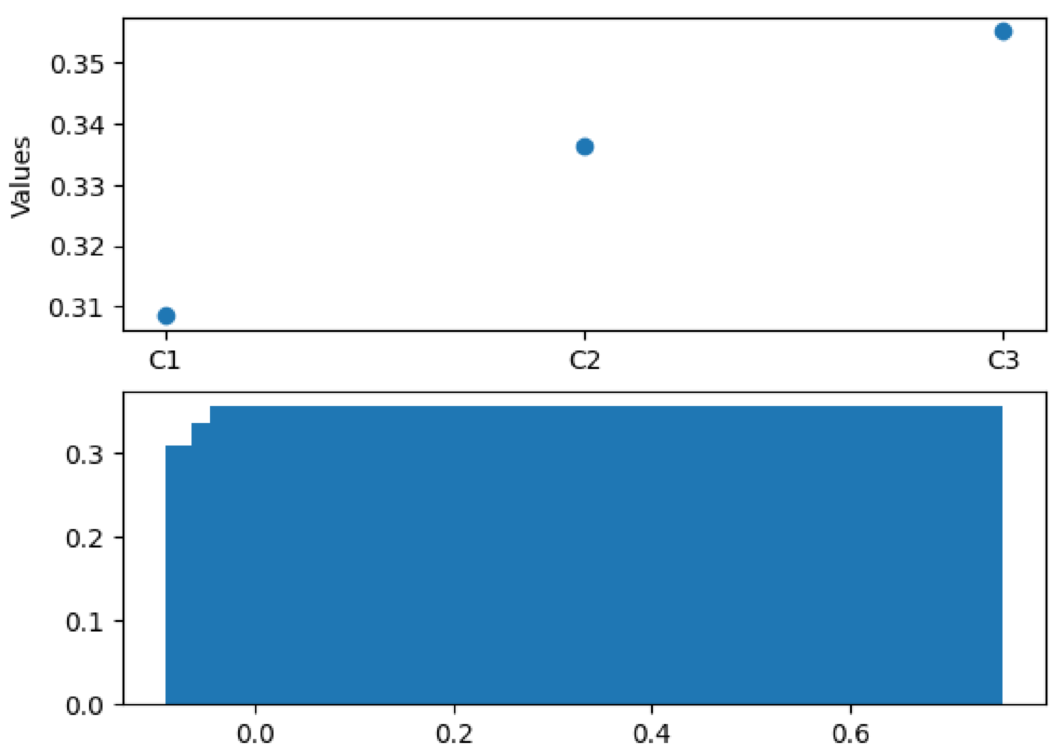

Fig 12. Weights of fifth sub criterion.

Then we compute the criteria weights in the sixth sub criteria. We create the decision matrix between the criteria and alternatives. We combine the decision matrix as shown in Fig 13. We compute the criteria weights using the average method as shown in Fig 14.

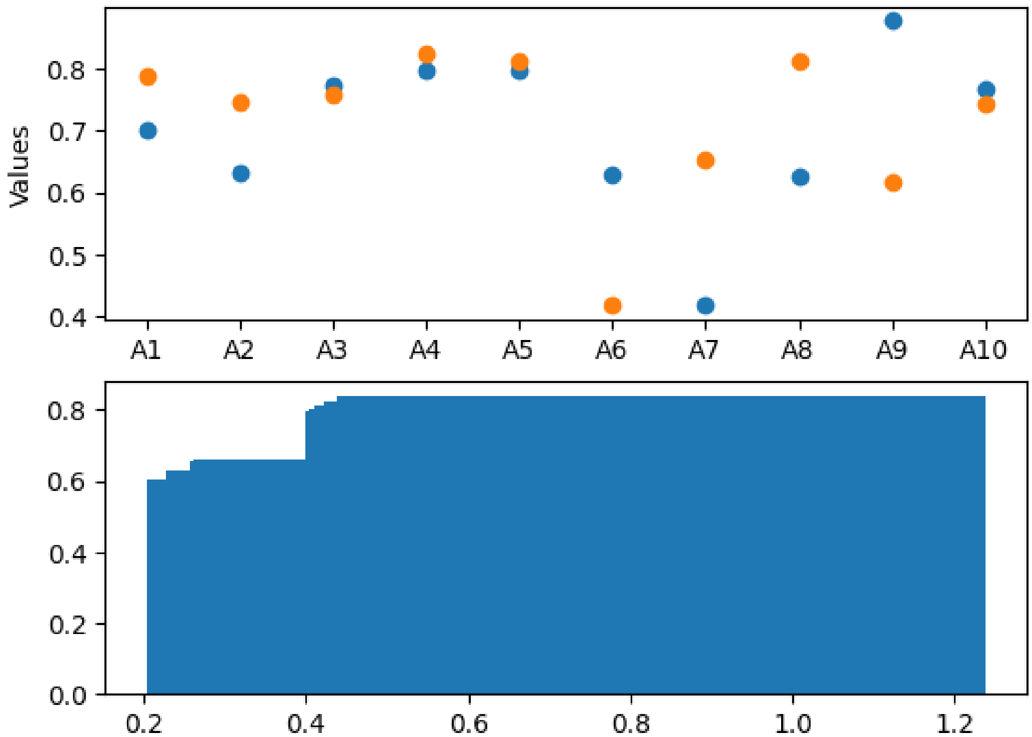

Fig 13. Combined decision matrix for sixth sub criterion.

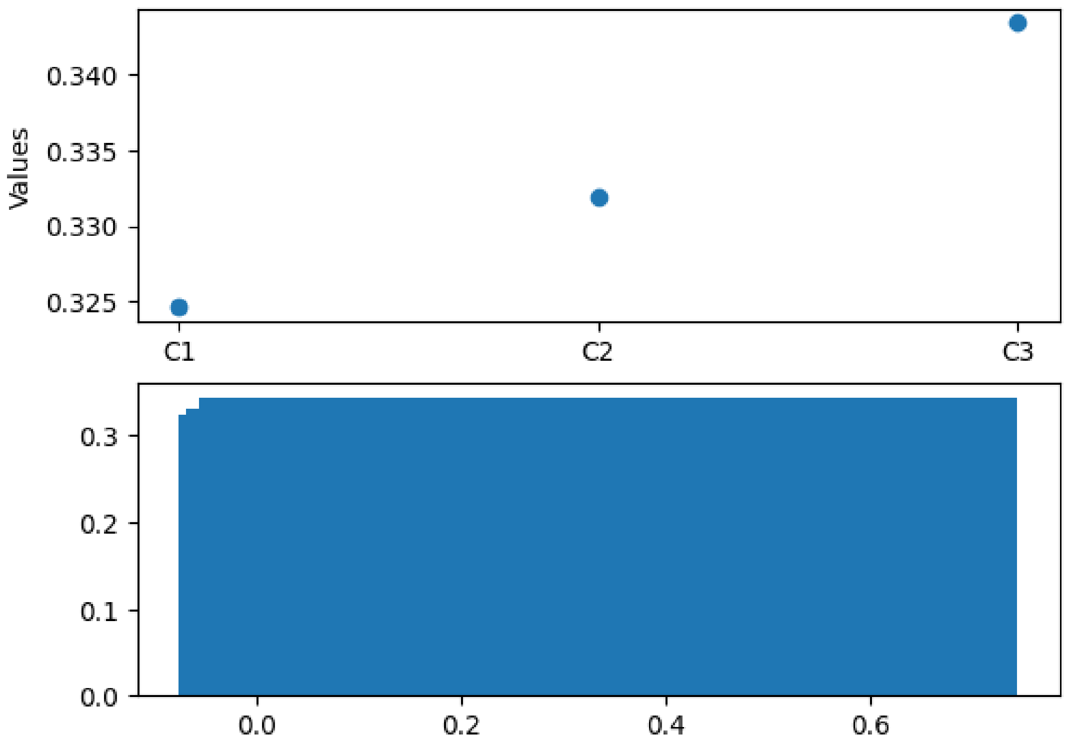

Fig 14. Weights of sixth sub criterion.

Then we compute the weights of global criteria by multiplying the weights of main criteria by the weights of sub criteria as shown in Fig 15. Then we rank the alternatives using the WSM method.

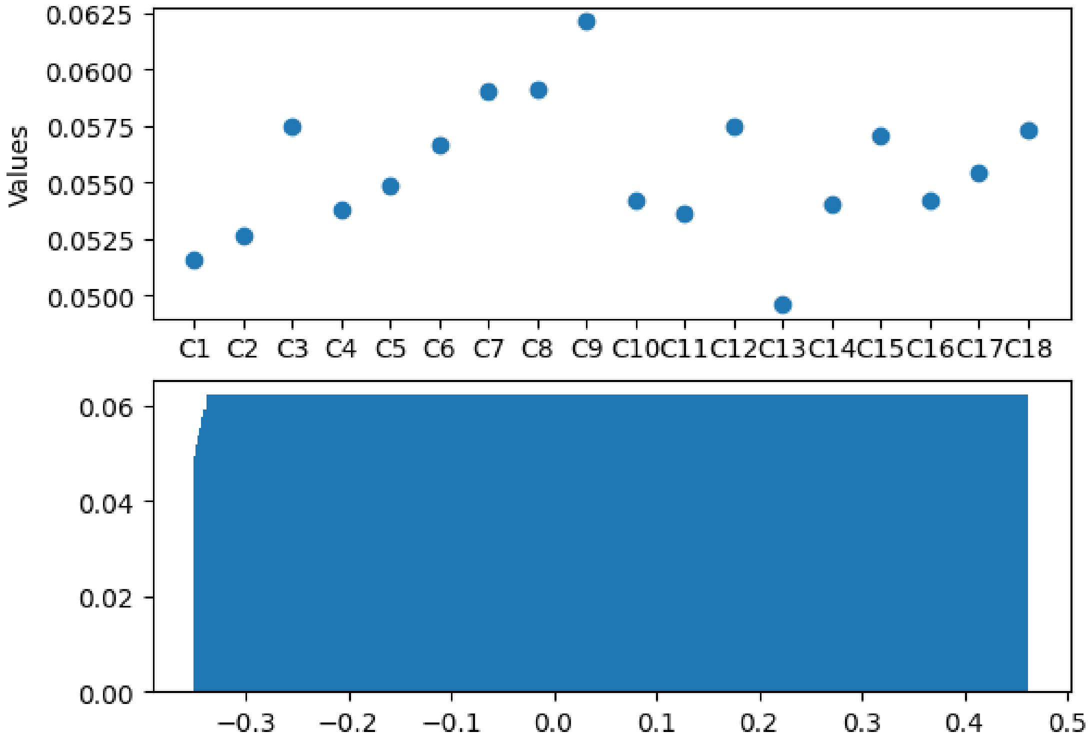

Fig 15. The weights of global criteria.

We show the steps of the WSM method to rank the alternatives.

We compute the weighted decision matrix using eq. (14) as shown in Fig 16.

We compute the total sum of weighted decision matrix using eq. (15) as shown in Fig 17.

We rank the alternatives as shown in Fig 18.

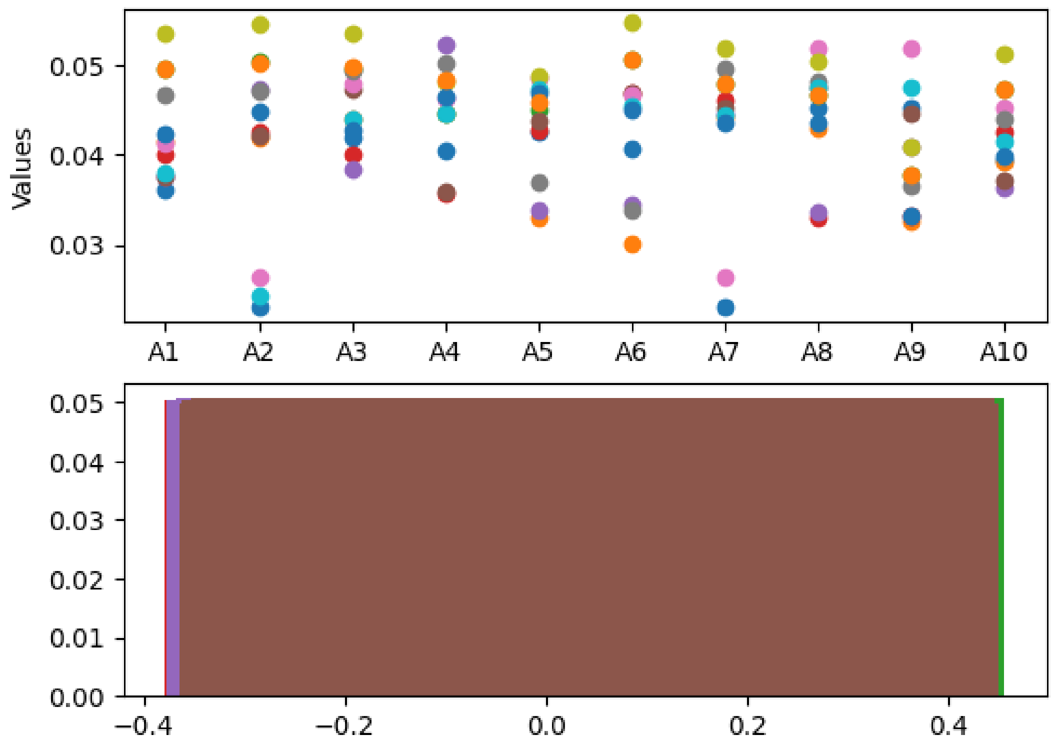

Fig 16. The weighted decision matrix.

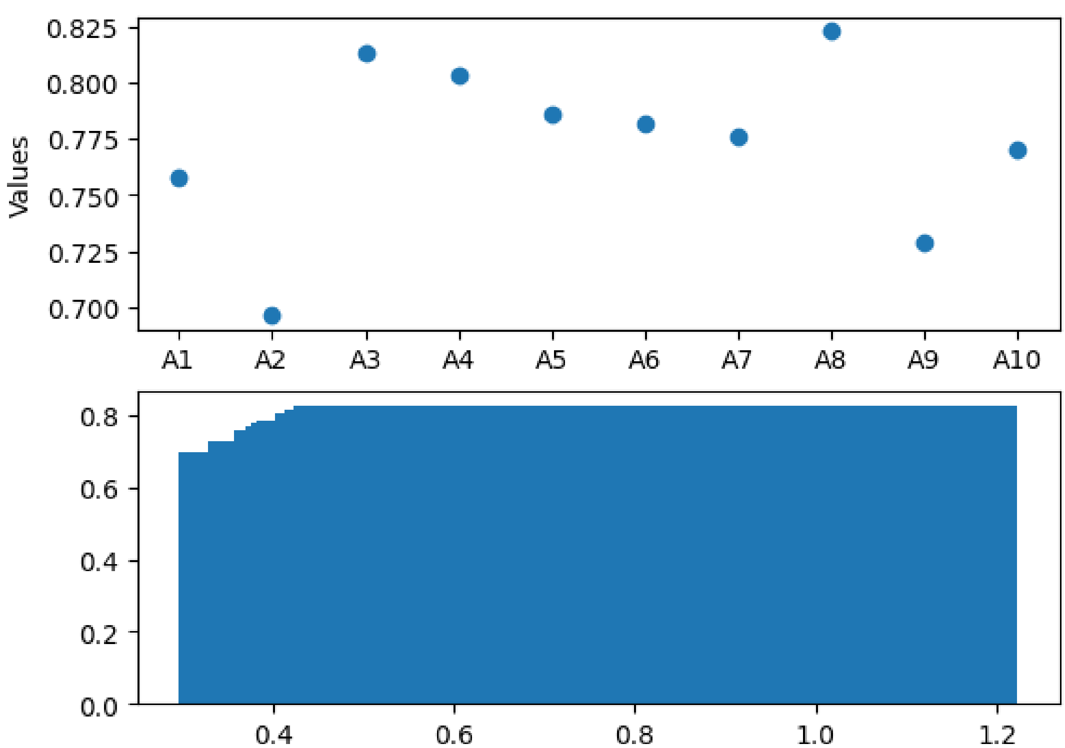

Fig 17. The total sum weight.

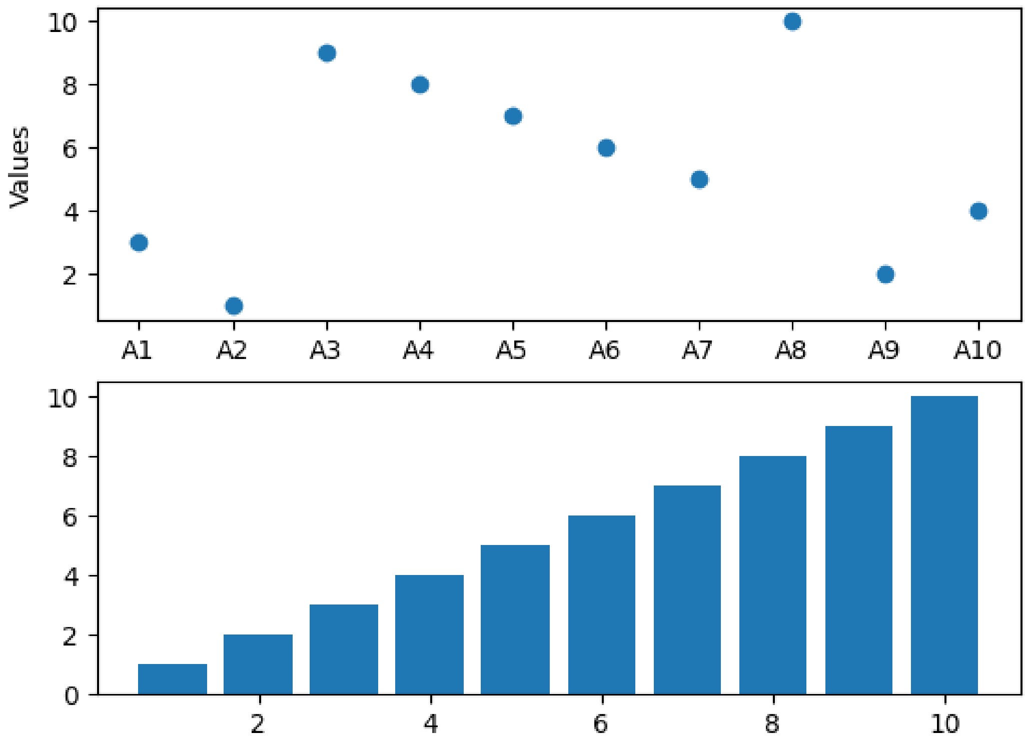

Fig 18. The rank of alternatives.

5. Conclusions

There are opportunities as well as challenges associated with integrating blended learning into middle school physical education. Although it could make physical education more adaptable, inclusive, and customized, its effectiveness depends on several interconnected elements, including the caliber of instruction, student participation, teacher support, and technological preparedness. This study highlights how crucial it is to assess integrated physical education programs holistically and according to clear standards to make sure that learning objectives are in line with developmental and health objectives. The evaluation's conclusions can direct the creation and execution of more successful physical education programs, which will ultimately result in student populations that are healthier and more active. We used the TreeSoft Set to divide the criteria as a tree and we computed the weights in each level. We rank the alternatives using the WSM method.

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