Assessment of the Educational Live Action in Uncertainty Environment under Single-Valued Neutrosophic Sets

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Abstract

Health professional educators are increasingly using escape rooms as a teaching tool. Given the fast development in their use, investigators have chosen varied assessment approaches to evaluate the instructional rooms. Considering educational escape rooms is a multi-attribute decision-making (MADM) process based on various criteria. This study proposed a MADM model to assess the educational escape rooms. This study used the VIKOR MADM method to evaluate the criteria and alternatives. This evaluation is made under a neutrosophic set to overcome the uncertainty information. We collected fourteen criteria and ten alternatives in this study. We employed a sensitivity analysis to show the proposed model's effectiveness and the results' stability. The analysis shows the results are stable.

Keywords: Neutrosophic Sets; Educational Escape Rooms; Learning,;Uncertainty; MCDM Methods.

1. Introduction

Live-action, team-based games where participants find clues, solve riddles, and complete tasks in one or more rooms to achieve a specified objective... in a limited period of time are what escape rooms are all about. In 2007, the first escape room was launched in the entertainment business, with inspiration drawn from video games. Since then, the popularity of the idea has skyrocketed, and escape rooms are now available all over the globe[1]–[3]. As escape rooms continue to rise in popularity as a leisure activity, educators are beginning to notice the educational potential of the format and incorporate it into their own classrooms. The sector of health professions education stands out as a pioneer user of educational escape rooms for this same reason[4]–[6].

Educational escape rooms offer a sort of game-based learning, wherein learning goals are mostly accomplished via the use of a game. Due to declining student interest and motivation, game-based learning emerged as a viable educational strategy. Games have been found to improve player engagement, motivation, and productivity via the elicitation of positive feelings such as pleasure, competitiveness, attention, and achievement[7], [8]. Therefore, in order to increase students' engagement, motivation, and productivity while studying, game-based learning seeks to

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channel these feelings.[9], [10] A recent systematic study on the usage of all types of gamified learning in higher education found various advantages of this educational strategy, therefore the research seems to back up this idea. The levels of interest, motivation, self-assurance, perspective, perception, and even actual academic and athletic achievement were all improved. Therefore, the use of game-based learning, such as educational escape rooms, is likely to grow in the future years[11]–[13].

Medical, nursing, pharmacy, occupational, and physical therapy are just a few of the healthcare specialties that have included escape rooms in their curriculum. They are used at all levels of education from primary school to graduate school and beyond. Learning objectives as varied as 'technical' and 'non-technical' information and skills have been taught using escape rooms[14], [15]. Goals in the fields of anatomy, dermatology, and sepsis detection and treatment are all examples of technical learning objectives. Training collaboration, communication, and critical thinking are all examples of non-technical learning objectives. Patient safety, student orientation, and recruiting are just a few of the bigger ideas that have been investigated[16], [17].

Choosing an environment to offer assessment ratings of characteristics with regard to options is a primary issue for a decision-maker (DM) while confronting multi-attribute decision-making (MADM) difficulties in the real world. The actual world is full of inaccuracies, unknowns, and ambiguities, making it difficult for a DM to choose the best option from a collection of possibilities based on a variety of traits about which they are unsure[18]–[20]. Due to its impressive ability to represent ambiguous information, the concept of fuzzy sets (FSs) has garnered the interest of numerous academics. Atanassov introduced intuitionistic fuzzy sets (IFSs) as an enhancement of FSs; in IFSs, the sum of an element's membership degree (MD) and non-membership degree (NMD) is less than or equal to 1[21]–[23]. Due to its ability to concurrently address both the MD and the NMD of an element belonging to an IFS, the notion of IFSs is highly helpful in dealing with imprecision and indeterminacy. Some MADM approaches have been suggested based on IFSs. Yager presented the notion of Pythagorean fuzzy sets (PFSs) as a way to improve upon IFSs; PFSs permit the squared sum of the MD and the NMD of an element to be less than or equal to 1. Since PFSs were proposed, it has been the subject of much study by scholars from various disciplines[24]–[26].

Smarandache's Neutrosophic Sets (NSs) are a broader concept than both Fuzzy Sets (FS) and Intuitionistic FS (IFS). An element's degree of Truth Membership (TM) in a given set may be obtained from the FS, whereas the degrees of False Membership (FM) and Indeterminacy Membership (IM) can be obtained from the IFS and the NS[27]–[29]. Unlike in FS, where FM is entirely decoupled from the TM function in IFS, this is not the case in FS. The NS TM, IM, and FM functions are all decoupled. Smarandache explained the distinctions between NSs and the several FS extensions that have been proposed. Smarandache's research inspired a variant of NS called Single-Valued NS (SVNS)[30], [31].

Many approaches for addressing MADM issues have been proposed in recent years. There are benefits and drawbacks to each of these approaches. To cope with MADM difficulties, Opricovic presented a compromise index-based MADM strategy, termed the VIKOR method. Like the TOPSIS model, the VIKOR technique ranks options by using reference points. Multiple approaches have been used in using the VIKOR technique.

The main contributions of this study are:

The weights of the criteria are determined and the criteria of educational escape rooms are ranked using a neutrosophic set.

It is the first study to evaluate the educational escape rooms under a neutrosophic set with an uncertain environment.

The neutrosophic sets are used to overcome the uncertainty information in the assessment process.

The alternatives are ranked according to the neutrosophic VIKOR method.

The criteria and alternatives are gathered according to the previous research, and interviews with experts and decision-makers.

2. Neutrosophic Sets

This section introduces some mathematical equations to describe the neutrosophic numbers operations and then introduces the steps of the neutrosophic VIKOR method.

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2.1 Single Valued Neutrosophic Sets (SVNSs)

In this part, we introduce some operations on SVNSs as:

Let $x = (x_1, x_2, x_3)$ *and* $y = (y_1, y_2, y_3)$ to be single-valued neutrosophic numbers (SVNNs)

$$x \oplus y = (x_1 + y_1 - x_1 y_1, x_2 y_2, x_3 y_3) \tag{1}$$

$$x \otimes y = (x_1 y_1, x_2 + y_2 - x_2 y_2, x_3 + y_3 - x_3 y_3) \tag{2}$$

$$\tau x = (1 - (1 - x_1)^\tau, x_2^\tau, x_3^\tau) \tag{3}$$

$$x^\tau = (x_1^\tau, 1 - (1 - x_2)^\tau, 1 - (1 - x_3)^\tau), \tau > 0 \tag{4}$$

The score value and the accuracy value can be computed as:

$$S(x) = \frac{(1 - x_1 - 2x_2 - x_3)}{2} \tag{5}$$

$$A(x) = x_1 - x_2(1 - x_1) - x_3(1 - x_2) \tag{6}$$

2.2 Neutrosophic VIKOR

In this part, we introduce the steps of the neutrosophic VIKOR method shown in Figure 1 as follows:

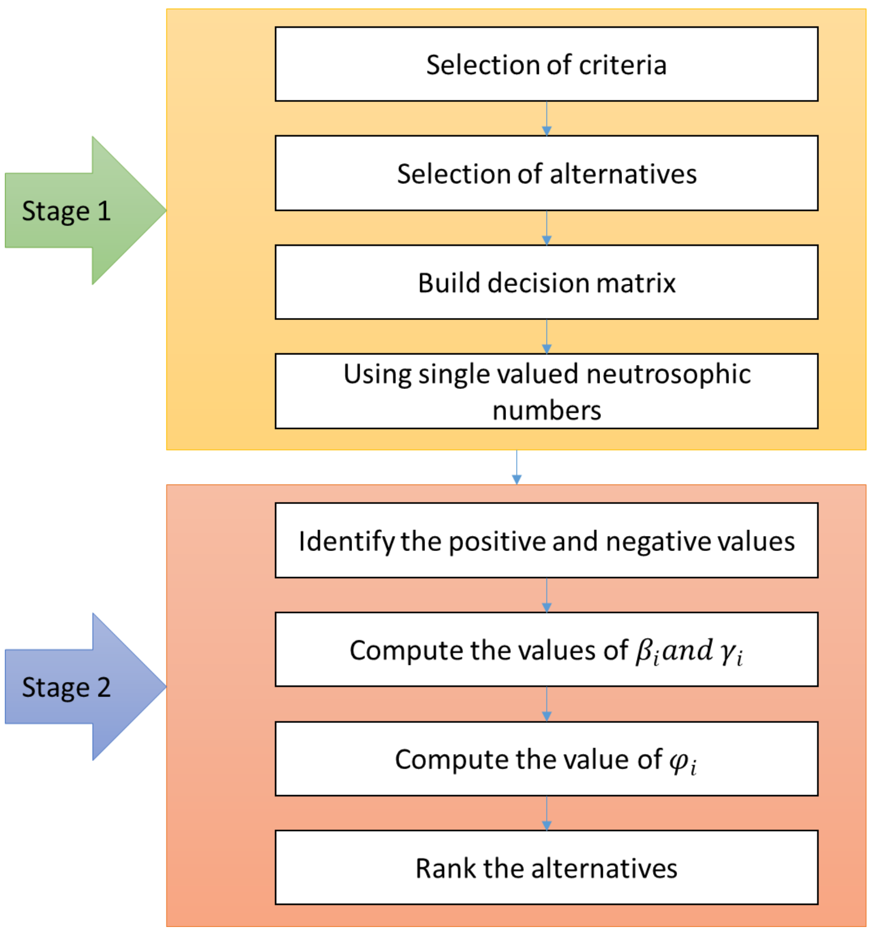

Figure 1: The steps of the proposed model.

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Step 1. Build the decision matrix

We identify the number of criteria and alternatives to build the decision matrix. The experts and decision-makers are evaluated the criteria and alternatives to build the decision matrix.

$$T_{M\times N} = \begin{bmatrix} t_{11} & \cdots & t_{1N} \\ \vdots & \ddots & \vdots \\ t_{M1} & \cdots & t_{MN} \end{bmatrix} \tag{7}$$

Where $i = 1,2,3, \dots M; j = 1,2,3 \dots N$

Step 2. Identify the positive and negative values

After building the decision matrix between the criteria and alternatives, we identify the positive and negative values as

$$\left(t_{ij}\right)_{max} = {}^{max}{}_{i}t_{ij}^{i} = \max\left[t_{ij}, i = 1,2,3, \dots . M\right] \tag{8}$$

$$\left(t_{ij}\right)_{min} = {}^{min}{}_{i}t_{ij}^{i} = \min\left[t_{ij}, i = 1,2,3, \dots . M\right] \tag{9}$$

Step 3. Compute the values of $\beta_i and\ \gamma_i$

We compute the utility measure β_i and the regret measure γ_i for positive and negative criteria:

$$\beta_i = \sum_{j=1}^{N} \frac{w_j\left[\left(t_{ij}\right)_{max} - t_{ij}\right]}{\left[\left(t_{ij}\right)_{max} - \left(t_{ij}\right)_{min}\right]} \tag{10}$$

$$\beta_i^- = \sum_{j=1}^{N} \frac{w_j\left[t_{ij} - \left(t_{ij}\right)_{min}\right]}{\left[\left(t_{ij}\right)_{max} - \left(t_{ij}\right)_{min}\right]} \tag{11}$$

$$\gamma_i = \max\left\{\frac{w_j\left[\left(t_{ij}\right)_{max} - t_{ij}\right]}{\left[\left(t_{ij}\right)_{max} - \left(t_{ij}\right)_{min}\right]}\right\} \tag{12}$$

Step 4. Compute the value of φ_i

$$\varphi_i = \delta\left[\frac{(\beta_i - \beta_i^-)}{(\beta_i^+ - \beta_i^-)}\right] + (1-\delta)\left[\frac{\gamma_i - \gamma_i^-}{\gamma_i^+ - \gamma_i^-}\right] \tag{13}$$

$$\begin{cases} \beta_i^+ = {}^{max}{}_{i}\beta_i = \max[\beta_i, i = 1,2,3 \dots M] \\ \beta_i^- = {}^{min}{}_{i}\beta_i = \min[\beta_i, i = 1,2,3 \dots M] \\ \gamma_i^+ = {}^{max}{}_{i}\gamma_i = \max[\gamma_i, i = 1,2,3 \dots M] \\ \gamma_i^- = {}^{min}{}_{i}\gamma_i = \min[\gamma_i, i = 1,2,3 \dots M] \end{cases}$$

Step 5. Rank the alternatives

The alternatives are ranked based on the lowest value of φ_i.

3. Outcomes

This section introduces the results of the neutrosophic VIKOR method.

Step 1. Eq. (7) is used to build the decision matrix by the criteria and alternatives. We let the experts and decision-makers evaluate the criteria and alternatives by the single-valued neutrosophic numbers. Then we used Eq. (5) to apply the score function to obtain the crisp values. We collected fourteen criteria and ten alternatives to evaluate in this study as shown in Figure 2. Then compute the weighted normalized decision matrix as shown in Table 1.

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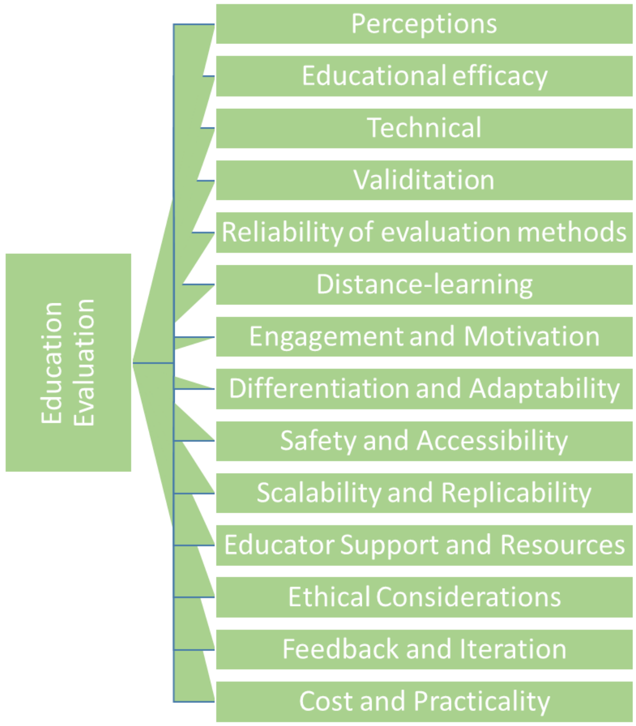

Figure 2: The set of criteria.

Table 1. The weighted normalized decision matrix.

	ESR1	ESR2	ESR3	ESR4	ESR5	ESR6	ESR7	ESR8	ESR9	ESR10	ESR11	ESR12	ESR13	ESR14
ESA1	0.04824	0	0	0.053911	0.051421	0.037007	0.005077	0.009501	0.032443	0.012365	0.068496	0.071254	0.019151	0
ESA2	0.055738	0.025153	0.056841	0.038401	0.008785	0	0.057677	0.058942	0.054482	0	0.038411	0	0.048827	0.003533
ESA3	0	0.030554	0.077278	0.001629	0.07063	0.038253	0.040618	0.049441	0.054459	0.030358	0.015093	0.026521	0	0.081789
ESA4	0.004844	0.061726	0.056036	0.053911	0.06981	0.026173	0.000203	0	0	0.009552	0	0.061794	0.014326	0.087796
ESA5	0.033642	0.050924	0.042535	0.087265	0.000234	0.057812	0.049351	0.003321	0.054034	0.022435	0.031789	0.059761	0.024852	0
ESA6	0.054278	0.075768	0.056381	0.040869	0.051421	0.026173	0.040347	0.052762	0.054034	0.022435	0.060299	0.026521	0.013303	0.085676
ESA7	0.00073	0.092542	0.042535	0.053948	0	0.025886	0.022543	0.022138	0.01074	0.047092	0.002095	0.03324	0.073094	0.052465
ESA8	0	0.034103	0.077789	0.089733	0.070279	0.054552	0.002031	0.023983	0.024612	0.002221	0.056382	0.061529	0.05716	0.086382
ESA9	0.028997	0.093051	0.043429	0	0.074964	0.065098	0.040347	0.03376	0.05437	0.052534	0.032426	0.059761	0.05849	0.069954
ESA10	0	0.034566	0.076639	0.003788	0.036662	0.010738	0	0.048888	0	0.000963	0.015029	0.003183	0.076018	0.104224

Step 2. Eqs. (8 and 9) are used to identify the positive and negative values. All criteria are positive except the cost is a negative criterion.

Step 3. Eqs. (10, 11 and 12) are used to compute the values of $\beta_i and\ \gamma_i$.

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Step 4. Eq. (13) is used to compute the value of φ_i as shown in Figure 3.

Step 5. Rank the alternatives as shown in Figure 3

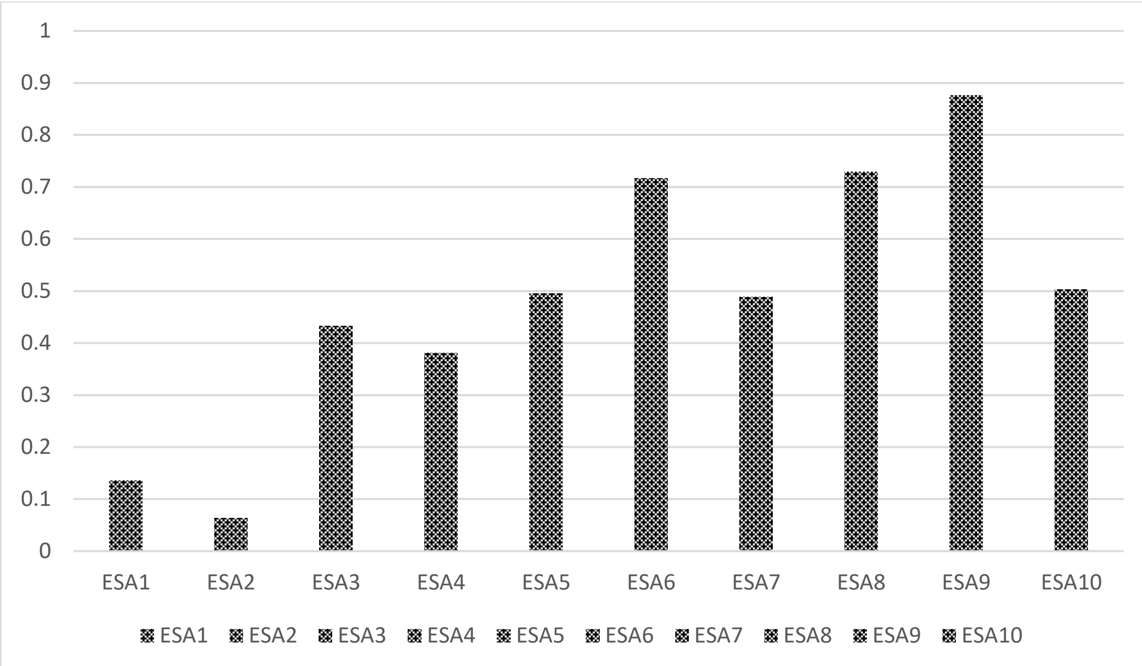

Figure 3: The rank of alternatives.

4. Sensitivity Analysis

We change the weights of criteria under fourteen cases as shown in Figure 4. We put one criterion with 0.01 weights and all other weights are equal. Then rank the alternatives to show the stability of the proposed model. We show that alternative 4 is the best in all cases and alternative 9 is the worst in all cases as shown in Figure 5.

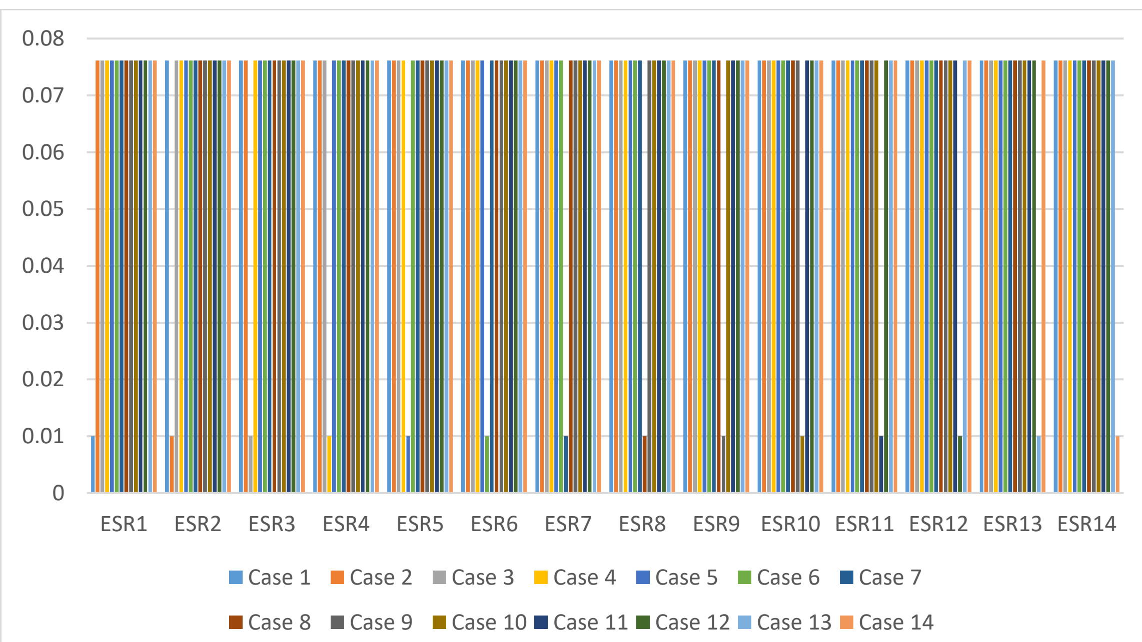

Figure 4: The fourteen cases in weights of criteria.

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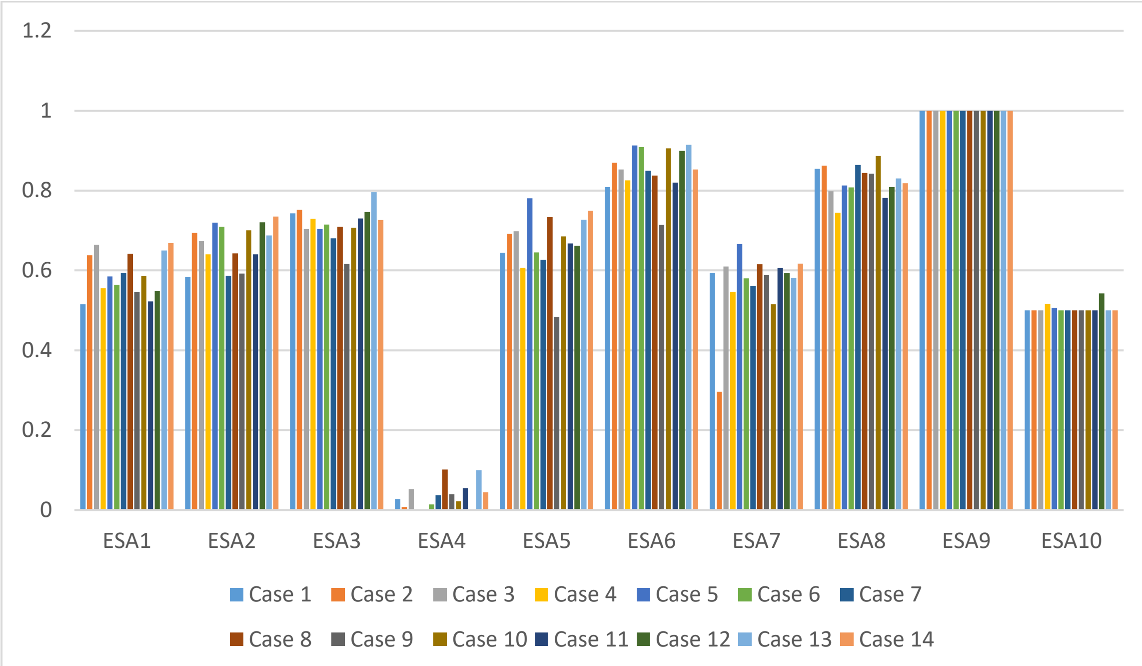

Figure 5: The rank of alternatives under fourteen cases.

5. Conclusions

In conclusion, it is crucial to assess the efficacy of educational escape rooms as tools and their influence on learning outcomes. Educators may evaluate the efficacy, applicability, and unity of escape rooms with learning outcomes using several factors.

Educators may evaluate whether escape rooms successfully engage and inspire students, develop their critical thinking and problem-solving capacity, encourage teamwork and communication, and help them apply what they've learned in the classroom to real-world situations via this assessment process. Content, distinction, evaluation, and feedback methods may all be evaluated for potential enhancements in this way.

Practicality and applicability in various educational contexts may be gained by assessing the educational escape room's safety, accessibility, cost-effectiveness, scalability, and reproducibility. The review method should also consider ethical aspects, such as the confidentiality of participants and the suitability of study materials.

Educators may make more well-informed judgments regarding whether or not to use educational escape rooms after reading evaluations of such activities. Improved learning experiences and results for participants are supported by its backing of the ongoing development of escape room design, implementation, and instructional methodologies.

The best practices, guidelines, and cutting-edge methods of using this immersive and engaging teaching tool will be developed as the educational environment continues to change, largely thanks to the continuous assessment and research on the success of escape rooms.

We proposed a neutrosophic MADM model for evaluating the criteria and alternatives in this study. We collected fourteen criteria and ten alternatives to assess the educational escape rooms. The MADM method uses the neutrosophic set to overcome the uncertainty information. The VIKOR method is used in this study to rank the alternatives. The sensitivity analysis shows that alternative 4 is the best and alternative 9 is the worst. Also, the sensitivity analysis shows the results are stable.

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