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Comparison methods in a decision support system for determining JavaScript frameworks

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ABSTRACT

The selection of an appropriate JavaScript framework in web-based software development often leads to errors when the chosen framework is incompatible with the design. The ability to make decisions quickly, accurately, and precisely is therefore a key factor in successful software design. Addressing this need, the present study analyzes the accuracy of the analytical hierarchy process-weight product (AHP-WP), analytical hierarchy process-technique for order preference by similarity to ideal solution (AHP-TOPSIS), and analytical hierarchy process-simple multi-attribute rating technique (AHP-SMART) methods in determining the most suitable JavaScript framework according to the International Organization for Standardization (ISO) 9126 classification. To evaluate accuracy, the mean absolute percentage error (MAPE) was applied as a cost function to measure the error percentage of each method. The analysis was conducted on ten popular JavaScript frameworks selected based on their popularity and usage trends. The evaluation considered six quality criteria: functionality, reliability, usability, efficiency, maintainability, and portability. The results show the ranking of each alternative for all methods. Accuracy measurement using MAPE revealed that the AHP-WP method produced the smallest error percentage (37.77645%), compared to AHP-TOPSIS (47.12566%) and AHP-SMART (46.4041%). Accordingly, the AHP-WP method is recommended for decision support system (DSS) development.

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1. INTRODUCTION

In information technology, decision support systems (DSS) serve as a bridge between information systems and machine learning. The ability to make decisions quickly, accurately, and precisely is essential in determining the appropriate course of action [1]. However, the availability of large amounts of information and data alone is not sufficient for effective decision making; the ability to analyze this information efficiently remains crucial [2], [3]. To ensure reliable outcomes, it is necessary to establish clear criteria before evaluating various alternatives. Each criterion must address the fundamental question of how effectively an alternative solves the problem at hand [4], [5].

A DSS is an information system that provides access to relevant information and facilitates data modeling and manipulation [6]-[8]. A DSS can be applied in both structured and unstructured decision-making scenarios, where identifying the most appropriate solution may be challenging [9], [10] Within this scope, a DSS functions as a tool that assists decision makers in selecting the best alternative to address a given problem [6]. Various DSS methods exist, each with distinct characteristics and analytical approaches. Commonly used methods include analytical hierarchy process (AHP), simple multi-attribute rating technique (SMART), weight product (WP), and technique for order preference by similarity to ideal solution (TOPSIS), among others [11].

In practice, DSS are widely applied in various real-life contexts [12]. One such application is in selecting the appropriate framework for web-based software development, where DSS can help reduce errors in decision making. Developers frequently encounter difficulties in determining which framework to adopt for their projects [13]. In this process, the selection is influenced by the criteria that must be considered, which should align with the standards defined by the developer. However, in evaluating whether a framework is suitable for addressing a given problem, software developers often face challenges in making the final decision [14], [15].

One of the most popular programming languages in software development is JavaScript [16], [17]. Numerous JavaScript frameworks have been developed and are commonly applied in projects ranging from small and medium scale applications to highly complex systems [18]. However, given the wide variety of available frameworks, developers often face difficulties in determining which framework best meets the criteria relevant to their design needs [19], [20]. To address this, the International Organization for Standardization (ISO) 9126 classification provides a reference standard for evaluating criteria that can help developers make more informed framework selections [21]. In this study, the evaluation focuses on ten popular JavaScript frameworks Angular, React, Vue, Solid, Next, Astro, Nuxt, Express, Svelte, and Gatsby, that represent widely adopted tools in modern web development.

The accuracy of decision-making outcomes is also influenced by the selection of a method that best fits the data. To improve the quality of results, comparisons can be conducted between methods with different characteristics and analytical approaches [22]. Based on this premise, the author was motivated to conduct research analyzing the accuracy of four decision support methods AHP, SMART, WP, and TOPSIS using the mean absolute percentage error (MAPE) as the evaluation metric for JavaScript framework selection. The primary objective of this study is to identify which method provides the most accurate results in decision making for JavaScript framework selection.

In this research, the author also refers to previous studies that have applied decision support system (DSS) methodologies in both software selection and JavaScript framework comparison. Hanine *et al.* [23] proposed an integrated AHP-TOPSIS methodology for selecting extract, transform, load (ETL) software, demonstrating that the combination of AHP to determine weights and TOPSIS to rank alternatives can produce structured, objective, and reliable results when multiple conflicting criteria are involved. Meanwhile, Ockelberg and Olsson [24] carried out a comparative study of three JavaScript frameworks angular, react, and vue evaluating them based on performance, modularity, and usability, and further applying AHP to determine the ranking of the frameworks. These two studies provide a strong basis and justification for this study: the first provides methodological rigor in combining multi criteria decision making methods by analyzing and comparing the ranking results of each combined method, while the second provides relevance in evaluating JavaScript frameworks using a decision support approach. By leveraging the understanding of both, this study aims to expand the use of DSS methods not only in general software selection but also in a wider set of JavaScript frameworks and by analyzing the quality of the combined DSS methods and comparing their performance to obtain the most accurate combination of methods using the MAPE accuracy method which allows for a more comprehensive comparison across various criteria.

2. METHOD

The research method outlines the stages or processes undertaken to obtain the results of the study [25]. These stages involve analyzing the requirements and conducting experiments, as illustrated in Figure 1. The figure presents a flow diagram of the sequential stages carried out in this research.

2.1. Determine research object and scope

The first stage involves analyzing the research object. This study focuses on applying the most accurate approach by combining the AHP with several other DSS methods, namely WP, SMART, and TOPSIS. In addition, the research object includes JavaScript frameworks. Several frameworks were selected based on their high download rates and popularity compared to other JavaScript frameworks.

2.2. Literature study

At the literature review stage, the author collects information from a wide range of sources, including scientific articles, books, and previous studies related to the present research. This stage serves to provide a theoretical foundation that supports and strengthens the case study [26].

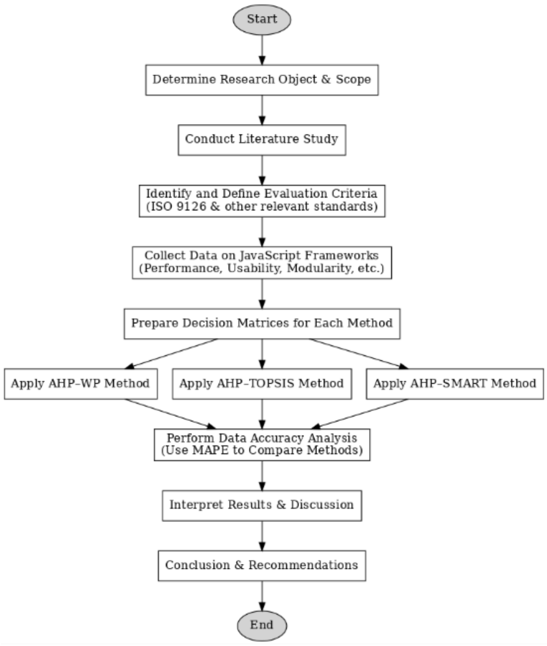

Figure 1. Research flowchart

2.3. Identify and divine evaluation criteria

This research adopts the ISO 9126 classification to define the criteria in accordance with the needs and accuracy of the data being analyzed. The software quality model described in the ISO 9126 standard, developed by the ISO and the International Electrotechnical Commission (IEC), consists of six quality criteria: maintainability, functionality, reliability, usability, efficiency, and portability [19].

2.4. Data collection

The third stage is data collection. In this stage, data were obtained from the JavaScript dependencies platform. The node package manager/npmjs registry provides official data related to frameworks, libraries, and dependencies. In addition, supplementary data were collected from the official websites of each JavaScript framework as well as from GitHub [27]. The dataset used in this research includes publicly available information provided by official framework sources and community websites, such as framework version, license type, file size, number of downloads, pull requests, runtime code, and others.

2.5. Implementation of the AHP-WP method

In this experiment, the author utilizes the characteristics of the AHP and WP methods. The overall experimental process of AHP-WP in this study is illustrated in Figure 2, which presents the flowchart of the AHP-WP experiment. The AHP-WP flowchart illustrates the stages of determining criteria weights using the AHP method through pairwise comparisons and consistency testing. The derived criteria weights are then applied in the WP method to normalize alternative values and perform weighted multiplication calculations.

The final output is an alternative ranking (AHP-WP ranking) that identifies the best framework according to the research criteria. The AHP method is particularly effective in providing accurate results for determining both criteria and sub criteria [28]-[30]. After establishing the criteria using AHP, a cross assessment is conducted with a rating scale of 1–9 based on Saaty's theory. This scale is used to determine the relative significance of each criterion through pairwise comparison [31]. Finally, the results of the pairwise assessments, presented in matrix form, are tested for consistency using the following steps [32], [33]:

a. Sum the values in each row ($\sum row$).
b. Divide the result of the row sum by the priority weight of the element concerned.

c. Add up the λ (lambda) values and divide them by the number of elements to get the maximum λ value with (1).

$$\lambda_{maks} = \frac{\sum \lambda}{n} \quad (1)$$

d. Calculate the consistency index (CI) with (2)

$$CI = \frac{(\lambda\, max - n)}{n-1} \quad (2)$$

Where n represents the total number of elements being compared.
e. Calculate the consistency ratio (CR) with (3)

$$CR = {CI}/{RC} \quad (3)$$

The random consistency (RC) is determined using the equation provided in Table 1. The consistency requirements are satisfied if the CI and CR values are below 0.10. However, if CR exceeds 0.10, the evaluation should be reconsidered [34], [35].

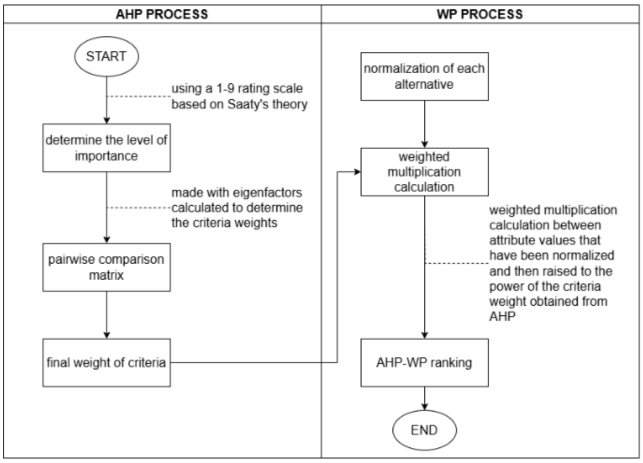

Figure 2. AHP-WP experiment flowchart

Table 1. RC values

Value	Training data
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51

The pairwise assessment produces a comparison matrix, from which eigenvectors are calculated to determine the criteria weights using the AHP method [32]. Meanwhile, the WP method is applied in the normalization of each attribute value of the alternatives. The calculation of preference values is then carried out as an initial step using (4), as [36], [37]:

$$S_i = \Pi_{j=1}^{n} \left(x_{ij}\right)^{\omega j} \quad (4)$$

In its implementation, S_i represents the final score of the i-th alternative, x_{ij} is the score of the i-th alternative according to the j-th criterion, ωj is the weight of the j-th criterion, and n denotes the number of criteria. The sum of the products is then used to calculate the V value for each alternative [36], [37]. The vector V value is calculated using (5).

$$V_i = \frac{\pi_{j=1}^{n} x_i j^{w_j}}{\pi_{j=1}^{n} x_j w_j} \quad (5)$$

In its use, V shows alternative preferences represented by vector V_i, w is the weight of the criteria, j is the criterion, x is the criterion value, n is the number of criteria, and i is an alternative. In the last stage, the final value of each alternative is calculated by multiplying the attribute values that have been raised [36], [37].

2.6. Implementation of the AHP-SMART method

Based on the pairwise evaluations conducted in the previous step, a pairwise comparison matrix is constructed, and eigenvectors are computed to determine the criteria weights using the AHP method. These final weights are then applied in the SMART process, as illustrated in the AHP-SMART experiment flowchart shown in Figure 3.

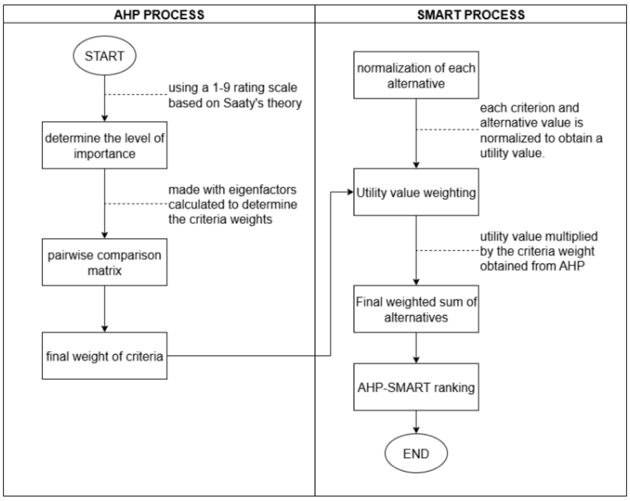

Figure 3. AHP-SMART experiment flowchart

The AHP-SMART flowchart illustrates the process of determining criteria weights using AHP through pairwise comparisons to obtain the final weights. These weights are subsequently applied in the SMART method by normalizing the alternative values to generate utility values. The final results are obtained by summing the weighted utility values of each alternative, producing an AHP-SMART ranking. In the SMART calculation, the normalized value of each criterion is multiplied by its weight relative to the total weight of all criteria, as expressed in (6) [38]-[41]:

$$\frac{w_j}{\Sigma w_j} \quad (6)$$

While normalizing the value using the SMART method, each criterion and alternative value is normalized to get the utility value with (7) [40], [41]:

$$ui(ai) = \frac{Cout - Cmin}{Cmax - Cmin} \% \quad (7)$$

Description:
– $ui(ai\ )$: the utility value of the 1st criterion for the i-th criterion
– $Cmax$: highest value criterion value
– $Cmin$: lowest value criterion value
– $Couti$: score for the i-th criterion

$$\bigcup_i(a_i) = \sum_{j=i}^{m} w_j u_i(a_i) \quad (8)$$

Determining the final value of each criterion is done by multiplying the result of the normalized value w_j of the criterion with the normalized weight of the criterion, then summing the results of the multiplication $ui\ (a_i)$ as in (8) [40]-[42].

2.7. Implementation of the AHP-TOPSIS method

From the pairwise assessment conducted in the previous step, a comparison matrix is constructed, and eigenvectors are calculated to determine the weight of each criterion using the AHP method. The resulting criteria weights are then applied in the TOPSIS process, as illustrated in the AHP-TOPSIS experiment flowchart in Figure 4.

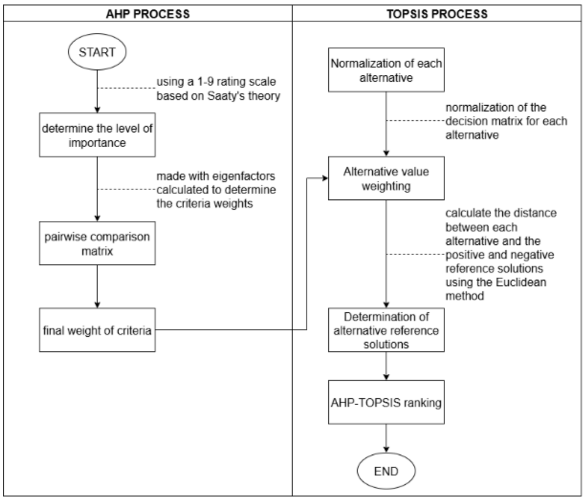

Figure 4. AHP-TOPSIS experiment flowchart

The AHP-TOPSIS flowchart illustrates the process of determining criteria weights using AHP through pairwise comparisons to obtain the final weights. The alternative values are then normalized and weighted, and their distances to the positive and negative reference solutions are calculated using the Euclidean method. The final outcome is an AHP-TOPSIS ranking, which identifies the best alternative based on its proximity to the reference solution. In the TOPSIS method, the reference solution is divided into two types: the positive reference solution (the maximum value for each criterion) and the negative reference solution (the minimum value for each criterion). The separation between each alternative and these reference solutions is determined using (9) for the positive reference and (10) for the negative reference, both of which employ the Euclidean method [43]-[45].

$$d_i^+ = \sqrt{\sum_{j=}^{m} 1 \left(y_{ij} - y_j +\right)^2} \quad (9)$$

$$d_i^- = \sqrt{\sum_{j=}^{m} 1 \left(y_{ij} - y_j -\right)^2} \quad (10)$$

Description:

- $y_j +$: elements of the positive reference solution matrix
- y_j-: elements of the positive reference solution matrix

Calculating the preference value for each alternative is necessary to rank each alternative [46], [47]. The preference value for each alternative must be calculated first, and this calculation can be seen in (11):

$$c_i = \frac{d_i}{d_i^- + d_i^+} \quad (11)$$

Alternatives can be ranked in order of preference value (c_i), with the value that is the shortest distance to the positive reference solution and the farthest distance to the negative reference solution is considered the best alternative, called the preference value [48], [49].

2.8. Data accuracy analysis

The data accuracy analysis stage aims to analyze and evaluate the final results of each experiment conducted [50]. Each final result value is collected and compared to assess whether the outcomes align with the research requirements. Furthermore, the accuracy is calculated using the MAPE method, with (12) applied to determine the accuracy of each JavaScript framework ranking [51]-[53].

$$MAPE = \frac{1}{m_k} \sum_{k=1}^{m} \left| \frac{t_k - y_k}{t_k} \right| * 100 \quad (12)$$

Description:
- t_k: actual value
- y_k: forecasted value
- m_k: number of data used

The process involves comparing each experiment to determine which one yields the highest level of accuracy in making JavaScript framework selection decisions.

3. RESULTS AND DISCUSSION

3.1. Data collection

The data collection in this research consists of secondary data obtained from the official websites of each JavaScript framework and from community websites. The collected data describe the capabilities of each framework. This process was conducted in January 2025 using data from the previous year, covering the period from January 2024 to December 2024. In total, ten JavaScript frameworks were selected as research alternatives: Angular, React, Vue, Solid, Next, Astro, Nuxt, Express, Svelte, and Gatsby. The data were then grouped according to the criteria defined in the ISO 9126 classification. This grouping includes six criteria maintainability, functionality, reliability, usability, efficiency, and portability, which are presented in Table 2.

Table 2. JavaScript framework data on each criterion

No	Alternative	Criteria					
		Functionality	Reliability	Usability	Efficiency	Maintainability	Portability
1.	Angular	714100680.7	2423367896	30	10281566460	0.555635707	10
2.	React	4462338860	15143320312	10	64248222880	0.555637328	10
3.	Vue	17283828964	58662052852	75	2.48882	0.55556636	10
4.	Solid	74470986.67	251993967.1	4.5	1069297240	0.557158357	10
5..	Next	24274162.54	81127327.07	10	344482300	0.563725046	10
6.	Astro	805441.6931	1958013.598	0.2857	7778200	0.828409342	10
7.	Nuxt	214585.3221	602188.4953	0.285	2502840	0.685893855	9.4444444
8.	Express	992377.1933	1673786.919	0.192	5529440	1.435772437	6.6666667
9.	Svelte	4393558.074	14328721.8	7.35	59117840	0.594549202	9.4444444
10.	Gatsby	761327.5646	1828728.712	3.465	6402600	0.951273001	6.6666667

3.2. AHP-WP method comparison calculation

3.2.1. AHP calculation

In the AHP calculation, the process of inputting data for each alternative according to the previously gathered criteria in Table 2. Once the data is collected, it is essential to establish the importance ratio for each criterion [32]. The value of the importance ratio of each criterion in Table 3.

Table 3. Importance ratio value

Criteria	Weight
Functionality	5
Reliability	3
Usability	4
Efficiency	3
Maintainability	2
Portability	2

After getting the value of the importance ratio, the pairwise comparison matrix for each criterion is based on the value of the importance ratio, as in Table 4.

Table 4. Pairwise comparison matrix

Criteria	K_1	K_2	K_3	K_4	K_5	K_6
K_1	1	3	2	3	4	5
K_2	0.33333	1	3	3	3	2
K_3	0.5	0.33333	1	3	4	3
K_4	0.33333	0.33333	0.33333	1	2	2
K_5	0.25	0.33333	0.25	0.5	1	1
K_6	0.2	0.5	0.33333	0.5	1	1
Total	2.616667	5.5	6.916667	11	15	14

Then the results of the importance ratio matrix are normalised using (2) as in Table 5. The steps taken to calculate the CR value can use (3). The value that needs to be obtained in calculating the CR value requires a vector weight value, which can be seen in Table 6.

Table 5. Normalisation of pairwise matrix

Criteria	K_1	K_2	K_3	K_4	K_5	K_6	Amount	Priority vector
K_1	0.382 166	0.545 455	0.289 157	0.272 727	0.266 667	0.357 143	1.756 171	0.2926 95119
K_2	0.127 389	0.181 818	0.433 735	0.272 727	0.2	0.142 857	1.215 669	0.2026 11488
K_3	0.191 083	0.060 606	0.144 578	0.272 727	0.266 667	0.214 286	0.935 661	0.1559 43519
K_4	0.127 389	0.060 606	0.048 193	0.090 909	0.133 333	0.142 857	0.460 43	0.0767 38298
K_5	0.095 541	0.060 606	0.036 145	0.045 455	0.066 667	0.071 429	0.304 413	0.0507 35542
K_6	0.076 433	0.090 909	0.048 193	0.045 455	0.066 667	0.071 429	0.327 656	0.0546 09366

Table 6. Weight vector of criteria

Criteria	K_1	K_2	K_3	K_4	K_5	K_6	Amount	Total priority
K_1	0.2926	0.6078	0.3118	0.2302	0.2029	0.2730	1.9186	6.5550
K_2	0.0975	0.2026	0.4678	0.2302	0.1522	0.1092	1.2596	6.2170
K_3	0.1463	0.0675	0.1559	0.2302	0.2029	0.1638	0.9668	6.1997
K_4	0.0975	0.0675	0.0519	0.0767	0.1014	0.1092	0.5045	6.5744
K_5	0.0731	0.0675	0.0389	0.0383	0.0507	0.0546	0.3234	6.3744
K_6	0.0585	0.1013	0.0519	0.0383	0.0507	0.0546	0.3555	6.5106
				Total				38.43132

The stage carried out after obtaining the criteria vector weight is to use (1) to get the value of the maximum lambda in the following way:

$$\lambda_{maks} = \frac{38.43132}{6} = 6.40522 \quad (13)$$

Furthermore, the calculation to obtain the CI value uses a (2), which then the value of the CI calculation results will be used in determining the CR value. In applying (2) to find the CI value, as follows:

$$CI = \frac{(6.40522-6)}{6-1} = 0.08104 \quad (14)$$

In calculating the CR value using (3), the CI value was obtained in the previous stage. In contrast, the value of RC was obtained based on the random value determined in Table 1. Based on Table 1, the RC value used is the value $(n) = 4$, which is 0.90. From the existing data, the calculations are carried out:

$$CR = \frac{0.08104}{0,9} = 0.0900492 \quad (15)$$

The result of the CR calculation is 0.0900492; this result shows that the CR value is <0.1, so the pairwise matrix used is consistent. The results for the final weight value of the criteria are obtained from the pairwise matrix values, which have been confirmed for consistency. The final criteria weights can be seen in Table 7.

Table 7. Final value of criteria weight

Criteria	Final weight
K_1	0.292695119
K_2	0.202611488
K_3	0.155943519
K_4	0.076738298
K_5	0.050735542
K_6	0.054609366

3.2.2. WP calculation

The first stage in the WP calculation is calculating the alternative value/S vector using (4), applying the formula as follows to obtain the results in Table 8.

$$S_i = (714100680.7^{0.292695119})(2423367896^{0.202611488})(30^{0.155943519})(10281566460^{0.076738298})(0.555635707^{0.050735542})(10^{0.054609366}) = 341318.9381 \quad (16)$$

Table 8. Total calculation value of s vector

Alternative	K_1	K_2	K_3	K_4	K_5	K_6	S-vector (V_i)
A1	390.348	79.687	1.699	5.865	0.970	1.133	341318.9381
A2	667.390	115.512	1.432	6.751	0.970	1.133	820334.9652
A3	991.989	151.982	1.960	7.490	0.970	1.133	2437088.989
A4	201.415	50.375	1.264	4.930	0.970	1.133	69626.36645
A5	145.076	40.039	1.432	4.519	0.971	1.133	41412.80278
A6	53.538	18.827	0.822	3.379	0.990	1.133	3146.892445
A7	36.352	14.826	0.822	3.097	0.981	1.130	1522.338128
A8	56.911	18.238	0.773	3.291	1.018	1.109	2984.087035
A9	87.967	28.179	1.364	3.948	0.973	1.130	14707.10486
A10	52.663	18.568	1.213	3.328	0.997	1.109	4371.742145
			Total				3736514.226

The results of the calculation to get the vector S value of each alternative against each criterion are then looked for the preference value V_i by dividing by the total value of vector S this process is carried out by (5) to get an alternative ranking, which can be seen in Table 9.

$$V_i(A1) = \frac{341318.9381}{3736514.226} = 0.091346886 \quad (17)$$

Table 9. Total preference calculation value Vi

Alternative	Preference value Vi
A_1	0.091346886
A_2	0.219545522
A_3	0.652235972
A_4	0.018634043
A_5	0.011083272
A_6	0.0008422
A_7	0.000407422
A_8	0.000798629
A_9	0.003936049
A_10	0.001170005

3.3. Comparison calculation of AHP-SMART method

3.3.1. AHP calculation

The results of the AHP calculation stage build upon the outcomes of the previous step to obtain the final weight values of the criteria, which have been tested for consistency using the consistency ratio. The final criteria weights presented in Table 7 are then applied in subsequent calculations to generate alternative rankings by comparing the AHP and SMART methods.

3.3.2. SMART calculation

In the first stage of SMART to determine the highest and lowest values for each criterion across all alternatives are presented in Table 10.

Table 10. Maximum and minimum value of each criterion

Criteria	Nature	Maximum value	Minimum value
Functionality	Benefit	17283828964	214585.3221
Reliability	Benefit	58662052852	602188.4953
Usability	Benefit	75	0.192
Efficiency	Benefit	2.48882E+11	2502840
Maintainability	Benefit	1.435772437	0.55556636
Portability	Benefit	10	6.666666667

After obtaining the results, the next stage is to perform calculations to find the utility value. The calculation is done using the equation formula based on the nature of each criterion. All criteria have benefit properties, so used (7), which is produced as shown in Table 11.

$$ui(ai) = \frac{714100680.7 - 214585.3221}{17283828964 - 17283828964} = 0.01209 \quad (18)$$

Table 11. Utility value

Alternative	K_1	K_2	K_3	K_4	K_5	K_6
A1	0.041304213	0.041301	0.398460058	0.041301	7.88E-05	1
A2	0.258170784	0.258137	0.131108972	0.25814	8.06E-05	1
A3	1	1	1	1	0	1
A4	0.004296347	0.004285	0.057587424	0.004286	0.001809	1
A5	0.001392045	0.001373	0.131108972	0.001374	0.009269	1
A6	3.41859E-05	2.31E-05	0.001253208	2.12E-05	0.309976	1
A7	0	0	0.001243183	0	0.148065	0.83
A8	4.50017E-05	1.83E-05	0	1.22E-05	1	0
A9	0.000241788	0.000234	0.095684953	0.000227	0.044288	0.83
A10	3.16336E-05	2.09E-05	0.043752005	1.57E-05	0.449561	0

After obtaining the results of the next utility value to get alternative rankings with the SMART method, it is necessary to multiply each criterion of the alternative by the final weight in Table 7; the (8). The results of this multiplication also provide the final results for alternative rankings, as seen in Table 12.

$$\bigcup_i(a_i) = (0.041304213 * 0.292695119) + (0.041301 * 0.202611488) + (0.398460058 * 0.155943519) + (0.041301 * 0.076738298) + (7.88\text{E} - 05 * 0.050735542) + (1 * 0.054609366) = 0.140377581 \quad (19)$$

Table 12. SMART final total results

Alternative	K_1	K_2	K_3	K_4	K_5	K_6	Total
A1	0.01209	0.008368	0.062137	0.003169	4E-06	0.054609366	0.140378
A2	0.075565	0.052302	0.020446	0.019809	4.09E-06	0.054609366	0.222735
A3	0.292695	0.202611	0.155944	0.076738	0	0.054609366	0.782598
A4	0.001258	0.000868	0.00898	0.000329	9.18E-05	0.054609366	0.066136
A5	0.000407	0.000278	0.020446	0.000105	0.00047	0.054609366	0.076316
A6	1E-05	4.68E-06	0.000195	1.63E-06	0.015727	0.054609366	0.070548
A7	0	0	0.000194	0	0.007512	0.045507805	0.053214
A8	1.32E-05	3.7E-06	0	9.33E-07	0.050736	0	0.050753
A9	7.08E-05	4.74E-05	0.014921	1.75E-05	0.002247	0.045507805	0.062812
A10	9.26E-06	4.24E-06	0.006823	1.2E-06	0.022809	0	0.029646

3.4. Comparison calculation of AHP-TOPSIS method

3.4.1. AHP calculation

The results of the AHP calculation stage build upon the outcomes of the previous step to obtain the final weight values of the criteria, which have been tested for consistency using the consistency ratio. The final criteria weights presented in Table 7 are then applied in subsequent calculations to generate alternative rankings through a comparison of the AHP and TOPSIS methods.

3.4.2. TOPSIS calculation

When normalizing the weighted matrix in the TOPSIS calculation, the normalized results must be used using the formula multiplied by the values of the final criteria weight. The final criteria weights used were obtained from the AHP method results, which are then multiplied by each normalized alternative value. The results of this multiplication can be seen in Table 13.

Table 13. Weighted matrix normalisation value

Alternative	K_1	K_2	K_3	K_4	K_5	K_6
A1	0.011699604	0.008097783	0.056685	0.003067024	0.011479	0.018543
A2	0.073109577	0.050602027	0.018895	0.019165452	0.011479	0.018543
A3	0.283172897	0.196021659	0.141712	0.074242391	0.011478	0.018543
A4	0.00122011	0.000842048	0.008503	0.000318975	0.011511	0.018543
A5	0.0003977	0.00027109	0.018895	0.00010276	0.011646	0.018543
A6	1.31961E-05	6.54278E-06	0.00054	2.32026E-06	0.017115	0.018543
A7	3.5157E-06	2.01224E-06	0.000539	7.46605E-07	0.01417	0.017513
A8	1.62588E-05	5.59303E-06	0.000363	1.64945E-06	0.029662	0.012362
A9	7.19827E-05	4.788E-05	0.013888	1.7635E-05	0.012283	0.017513
A10	1.24734E-05	6.11077E-06	0.006547	1.90992E-06	0.019653	0.012362

The positive reference solution matrix is determined by the highest (maximum) value of each criterion in the weighted normalized matrix. Conversely, the negative reference solution matrix is determined by the lowest (minimum) value of each criterion in the weighted normalized matrix. The results of this classification are presented in Table 14.

Table 14. Positive and negative reference solution matrix table

Reference	K_1	K_2	K_3	K_4	K_5	K_6
A+	0.283173	0.196022	0.141712	0.074242	0.029662	0.018543
A-	3.52E-06	2.01E-06	0.000363	7.47E-07	0.011478	0.012362

Calculations are carried out to obtain the gap or distance from each data point on the alternative to the positive reference solution matrix using (9):

$$d_i^+ = \sqrt{\begin{array}{c}((0.283173 - 0.011699604)^2) + ((0.196022 - 0.008097783)^2) + \\ ((0.141712 - 0.056685)^2) + ((0.074242 - 0.003067024)^2) + \\ ((0.029662 - 0.011479)^2) + ((0.018543 - 0.018543)^2)\end{array}} = 0.348768351 \quad (20)$$

While the calculation carried out is to get the gap or distance from each data point on the alternative to the negative reference solution matrix, using (10):

$$d_i^- = \sqrt{\begin{array}{c}(((3.52\text{E} - 06) - 0.011699604)^2) + \\ (((2.01\text{E} - 06) - 0.008097783)^2) + \\ ((0.000363 - 0.056685)^2) + (((7.47\text{E} - 07) - 0.003067024)^2) + \\ ((0.011478 - 0.011479)^2) + ((0.012362 - 0.018543)^2)\end{array}} = 0.058499027 \quad (21)$$

The results of each calculation to get the distance value of each alternative to the positive and negative reference solution matrix can be seen in Table 15.

Table 15. Table of alternative distances to positive and negative reference solutions

Alternative	D^+	D^-
A1	0.348768	0.0585
A2	0.289347	0.09303
A3	0.018185	0.37966
A4	0.375675	0.01033
A5	0.373076	0.01954
A6	0.379737	0.00837
A7	0.379857	0.00581
A8	0.379644	0.01818
A9	0.375105	0.0145
A10	0.37752	0.01025

The last stage is to get a ranking of alternatives using (11):

$$c_i = \frac{0.585}{0.585+0.348768} = 0.143638 \quad (22)$$

The results for all calculations on alternatives using (11) are presented in Table 16.

Table 16. Final score of TOPSIS method

Alternative	Final grade
A1	0.143638
A2	0.243286
A3	0.954291
A4	0.026767
A5	0.049775
A6	0.021559
A7	0.015077
A8	0.04571
A9	0.037206
A10	0.026435

3.5. JavaScript framework rating accuracy analysis

The analysis process to obtain accurate results from each comparison method is based on the data collected during the experiments. The data for each method are grouped according to both the method and the framework. Accuracy is then calculated using the MAPE method, following the (12). The accuracy results for each method are compared using the MAPE calculation, as presented in Table 17.

Table 17. MAPE value

Framework	AHP-WP	AHP-TOPSIS	AHP-SMART
Angular	50	50	50
React	27.77778	27.7778	27.77778
Vue	0	0	0
Solid	55.55556	116.667	116.6667
Next	77.77778	68.8889	68.88889
Astro	121.4286	121.428	94.94048
Nuxt	16.13757	16.1375	18.7037
Express	8.095238	43.6507	14.60317
Svelte	5.714286	17.7778	51.42857
Gatsby	15.27778	8.92857	21.03175
Average	37.77645	47.12566	46.4041

Analysis of the level of accuracy between the AHP-WP, AHP-TOPSIS, and AHP-SMART method comparisons results in the accuracy value of each method for each alternative, in Figure 5.

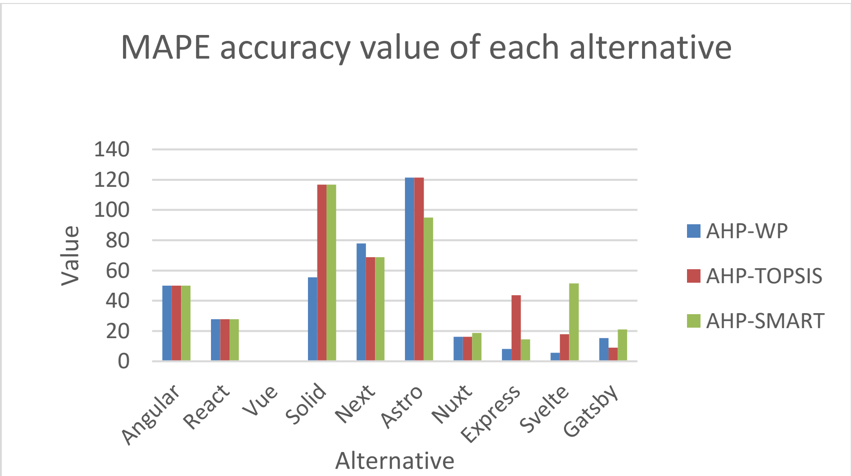

Figure 5. Graph of MAPE accuracy value of each alternative

The accuracy calculations for each alternative, as shown in Figure 5, indicate that the AHP-WP method produces the lowest error percentage overall. In particular, the Vue alternative consistently shows a 0% error across all methods, demonstrating its high accuracy. In contrast, the Solid and Astro alternatives exhibit high error percentages in all three comparison methods, as their final ranking results do not align with the specified ground truth.

Based on the results in Table 17, which present the accuracy calculations from the comparison of the AHP-WP, AHP-TOPSIS, and AHP-SMART methods in determining the JavaScript framework using the MAPE method, the AHP-WP method achieves a final accuracy of 37.77645%, the AHP-TOPSIS method 47.12566%, and the AHP-SMART method 46.4041%. Among these results, the AHP-WP method demonstrates the best accuracy, with the smallest error percentage, compared to the AHP-TOPSIS and AHP-SMART methods in determining the JavaScript framework based on the ISO 9126 classification criteria.

3.6. Discussion

The results of this research, which compared the AHP-WP, AHP-TOPSIS, and AHP-SMART methods for determining JavaScript frameworks based on the ISO 9126 classification, show that the AHP-WP method provides the most accurate results with the smallest percentage error according to the MAPE accuracy calculation. This study highlights the novelty of applying combined methods to achieve optimal accuracy, with AHP used for criteria weighting and other methods applied for alternative evaluation. Furthermore, the ISO 9126 classification was employed as a benchmark for selecting JavaScript frameworks, while the MAPE calculation was applied to evaluate accuracy values that had not been addressed in previous studies.

There is research from Suartini *et al*. [54] conducted a comparative study of AHP-SAW, AHP-WP, and AHP-TOPSIS methods in a decision support system for private tutor selection. The study involved ten tutor alternatives evaluated using five criteria, namely education level, teaching experience, teaching skill, teaching method, and tutor attitude. The accuracy of each method was assessed using MAPE by comparing system rankings with expert judgments. The results showed that AHP-TOPSIS achieved the highest accuracy with a MAPE of approximately 8.7%, followed by AHP-WP (10.4%) and AHP-SAW (13.2%). which can be seen in Table 18.

Table 18. Comparison of research with similar methods

Study	Methods used	Number of alternatives	Number of criteria	Accuracy results MAPE
Suartini *et al*. (2022)	AHP-SAW, AHP-WP, AHP-TOPSIS	Teacher (15 alternatives)	5 main criteria	- AHP-SAW 13.2% - AHP-WP 10.4% - AHP-TOPSIS 8.7%
(This study)	AHP-WP, AHP-TOPSIS, AHP-SMART	JavaScript framework selection (10 alternatives)	6 criteria (ISO 9126)	- AHP-WP 37.78% (best), - AHP-TOPSIS 47.13%, - AHP-SMART 46.40%

The findings of this research show notably different outcomes, with ten alternatives, more complex and varied data values, and a greater number of criteria six in total resulting in a MAPE accuracy value of 37.77646%. Factors such as the number of alternatives and criteria, data complexity, and numerical ambiguity can influence the final MAPE accuracy percentage for each method comparison.

4. CONCLUSION

In each comparison method, the calculation process based on the collected data was adjusted according to the ISO 9126 classification criteria, resulting in different rankings across the methods. However, the “Vue.js” alternative consistently ranked first in all methods. The final accuracy results using the MAPE method show that the AHP-WP method achieved the smallest error percentage of 37.77645%, while the AHP-TOPSIS method obtained 47.12566% and the AHP-SMART method 46.4041%. Based on these findings, the AHP-WP method demonstrates the highest accuracy, with a smaller error percentage compared to the other two methods. Therefore, the AHP-WP method is recommended, as the system to be designed and developed is more likely to provide accurate decision support results.

For future research, this study could be extended by evaluating a larger set of JavaScript frameworks, incorporating additional quality criteria beyond ISO 9126, or exploring hybrid approaches that combine multiple decision-making techniques. Moreover, applying the model to real world case studies in software development projects and comparing it with machine learning based approaches may offer deeper insights into the effectiveness and adaptability of decision support systems in framework selection. In this way, the study can provide valuable guidance for software developers when determining the most suitable JavaScript framework.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This research did not involve any human subjects or animal experiments. Therefore, approval from an institutional review board or ethics committee was not required.

DATA AVAILABILITY

The data supporting the findings of this study are obtained from publicly available online sources, including official JavaScript framework websites, JavaScript package repositories, and community analytics platforms (e.g., npmtrends.com, bestofjs.org, jsDelivr, Openbase, Libraries.io, BuiltWith, and cdnjs). All sources are publicly accessible and are cited within the article. No proprietary or restricted data were used in this study.

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