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Applying TOPSIS and AHP Intrinsic Properties to Explore Consumers' Preferences for Public Ceramic Relief Murals in Taiwan Region

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Abstract: Ceramic mural art is a contemporary landscape art, carefully designed based on human nature, culture, and architectural wall space; combined with social customs, visual sensibility, and art. It may also become the main axis of ceramic art in the future. The most distinctive feature of Taiwan region's public ceramic relief mural (PCRM) was pioneered by Pan-Hsiung Chu in 1987. In addition to breaking through the limitations of traditional PCRM, Chu uses local culture and perceptual art as themes, giving Taiwan region's ceramic wall art a unique style and innovative value. This study uses in-depth interviews with experts to analyze the intrinsic properties of AHP. At the same time, IPA is used as the public's preference evaluation, and TOPSIS analysis is applied to understand consumers' preferences for PCRM design imagery. It is hoped that this will sort out the key preferences of consumers and provide a reference basis and research methods for promoting PCRM in the Taiwan region.

Keywords: Interpretive structural modeling (ISM); STEEP analysis; PCRM; TOPSIS; IPA

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1. Introduction

Public ceramic relief mural (PCRM) is based on the art of ceramic art, which is the ultimate expression of charming aesthetics. The works over the past century are worth appreciating and savoring. Ceramic wall art is a modern landscape art. The design is based on humanized aesthetics, integration of local culture, customized theme features, and architectural space. It is carefully designed with visual sensibility and art. The creation of PCRM technology themes requires the design of digital technology to create elegant and perceptual works of art. Therefore, if ceramic art experts and artists want to become PCRM designers, they must cross the threshold of construction engineering and large-scale design. Nowadays, elites from all over the world are standing side by side. Yingge Ceramics is internationally famous, and Meinung Yao PCRM is proud of the Taiwan region, which has inspired research motivation. This article applies the five major S.T.E.E.P frameworks of caring design aesthetics, asks professionals to

select 8 factors, analyzes their core values and causal relationships, and then uses AHP intrinsic properties, TOPSIS, and other research methods to analyze the public's preference for PCRM. To enhance the reputation and value of PCRM, this study will explore the policy of sustainable inheritance so that unique and creative art can develop sustainably in the Taiwan region. It is hoped that this will sort out the key preferences of consumers and provide reference and research methods for promoting the Taiwan region's ceramic murals art.

2. Literature discussion

The origin of early Taiwan region's ceramic art can be traced back to Professor Song Guangliang (1909) who educated and promoted ceramic technology 38 years ago, cultivating ceramic art elites and laying a solid foundation. In the 1970s, when economic and information development took off, foreign artistic styles were absorbed, stirred up, and transformed into local culture. The artworks were exquisite and perfect, and the actual development of the Taiwan region's ceramic art was revealed.

In 1980, Dr. Chu upgraded the theme design of the Taiwan region's ceramic art application into the driving force of PCRM and was the most powerful person in founding and promoting it [1]. To this day, it has become a temporary trend and opened up the glorious history of the Taiwan region's ceramic mural art. Chu's "Beyond the Peak" works are spectacular and powerful as if flying thousands of miles into the sky, and full of aesthetic charm.

To find out the sustainable development of PCRM in the Taiwan region, STEEP was used as the five major frameworks. Experts selected the causal relationships of 8 main factors and then used AHP to determine the hierarchical analysis. Finally, TOPSIS-IPA was used to conduct a quantitative study on public satisfaction. It is expected that it will give the Taiwan region's ceramic mural art culture a more diverse presentation, provide the public with a reference for the meaning of PCRM, and use this and research methods to further inject it into industrial creative design [2].

3. Research design and methods

3.1. STEEP analysis

STEEP is based on the analysis of the development and changes of these environments in five aspects, including social environment, technological environment, economic environment, ecological environment, and political-legal environment. This analysis helps foresee and judge the opportunities and threats that market development brings to enterprises, providing a strong basis for further development. This study analyzed 5 aspects through STEEP and then sorted out PCRM-related preference factors as shown in **Table 1**.

Table 1. PCRM-related preference factors

Sociocultural trends	Factor 1: The perceptual value of PCRM can form a new cultural aesthetic. Factor 2: The ceramic mural artist should have good character, design, and a high reputation.
Technical principle orientation	Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art. Factor 4: Ceramics masters with artistic backgrounds and learning about building construction can become ceramic mural masters.
Economic factors	Factor 5: Promote lightweight ceramic mural art to the company's factories. Factor 6: Public agencies take the lead in promoting large-scale ceramic wall art, which can benefit craftsmen and promote international marketing.
Environmental issues	Factor 7: Universities offer ceramic mural design-related courses to cultivate talents, which is beneficial to employment and inheritance.
Political restrictions	Factor 8: The cultural department revised the PCRM law to only allow top ceramic mural masters to win the bid to ensure quality.

3.2. Analytic hierarchy process (AHP)

AHP is a multi-criteria decision-making method that transforms qualitative issues into quantitative analysis. It is characterized by building complex decision-making systems into hierarchical forms. Through orderly levels, a comparison matrix is formed for quantitative description based on the judgment structure of objective reality, which is the dual evaluation of each factor. Then use mathematical methods to calculate the relative weight of the elements at each level, and then obtain the relative weight of the elements between all levels and sort them as shown in **Table 2** [3]. The analytic hierarchy process generally uses the 1 to 9 relative proportion scale proposed by Professor Saaty [4].

Table 2. Proportional scale

Scale	Explanation
1	A1 and A2 are equally important
3	A1 is slightly more important than A2
5	A1 is more important than A2
7	A1 is much more important than A2
9	A1 is extremely important than A2

This study targeted 10 expert teachers from design-related departments in colleges and universities in the southern Taiwan region as questionnaire analysis subjects and used the AHP method to deal with decision-making problems. It is mainly divided into the following steps: establishing a hierarchical structure, using the golden ratio scale to design a pairwise comparison interview form for expert interviews, and establishing a pairwise comparison matrix. $R = (r_{ij})_{n \times n}$ calculate the weight sector M of each indicator factor M_i, where:

$$M_i = \frac{W_i}{\sum_i^n W_i} \quad W_i = \sqrt[n]{\pi_{j=1}^{n} r_{ij}} \tag{1}$$

$i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, n$ is the consistency index (C.I. < 0.1) and consistency ratio (C.R. < 0.1) detect whether there are inconsistencies in the decision-making analysis process, indicating the rationality of the calculated evaluation index weights. Finally, the relative weights of the elements at each level are integrated to calculate the total priority vector of the overall level [5].

3.3. Establishment of evaluation index

The research method is sent to experts in various fields through interviews, and the items that should be considered are compiled from the feedback of each expert. Then, the factors that should be considered are classified with similar properties and sent back to the experts to ask for their opinions. Finally, all the experts are gathered together to obtain the facet charm factor evaluation model, define the key factors, and then establish various classifications to establish the AHP. The hierarchical evaluation indicators are shown in **Figure 1** below.

At the same time, experts' opinions on the interrelationships between key factors are obtained as shown in **Figure 2**.

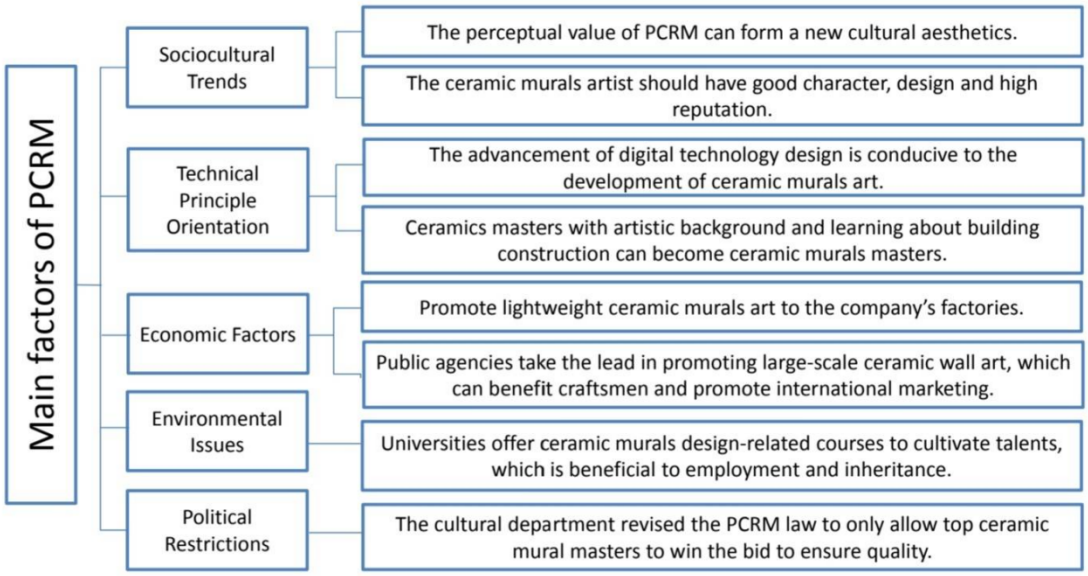

Figure 1. AHP level evaluation Index

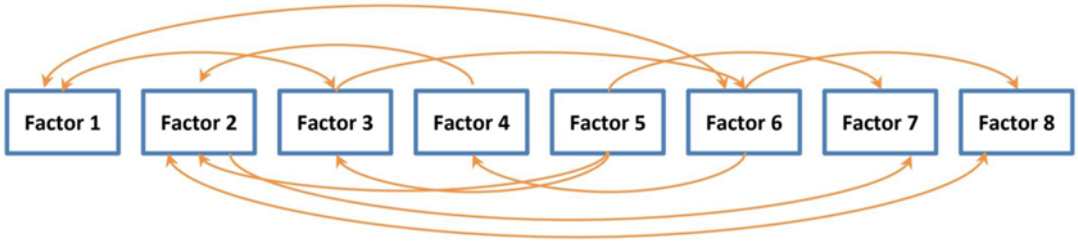

Figure 2. Dependency diagram

3.4. Important performance analysis (IPA)

This method can understand the extent to which customers value (Expectations) and actual feelings (Satisfaction) about the performance of goods or services. IPA plots these two subjective degrees of respondents into a two-dimensional matrix and divides them into four quadrants to obtain the order of priority improvements. Because IPA has the advantages of simplicity, effectiveness, and ease of understanding and use, it allows management units to make resource allocation decisions to improve overall performance. It has been widely used in the field of marketing management decision-making [6]. This study designed an IPA questionnaire to survey the PCRM design image preference attention and satisfaction among Taiwan region residents as an analysis and evaluation matrix for the ideal solution similarity ordinal preference method technique for order preference by similarity to ideal solution (TOPSIS).

3.5. Technique for order preference by similarity to ideal solution (TOPSIS)

The TOPSIS method is to evaluate the relative merits and demerits of the existing object and the ideal goal (Ideal solution). The optimal idealized goal is called a positive ideal solution, and the worst idealized goal is called a negative ideal solution. It adopts Euclidean distance to calculate distance. The problem of multi-attribute decision-making often results in decision-makers being unable to make smooth decisions due to conflicts between attributes. To solve the problem of decision-making, many decision-making methods have been proposed one after another. Hwang and Yoon proposed this method in 1981, and its calculation steps are summarized as follows.

Step 1. Establish a standardized evaluation matrix $R = (r_{ij})$ based on IPA and golden ratio scale semantics.

Step 2. Convert the semantic variables into a weight evaluation matrix $R = (r_{ij})$, which is the weight of each preference factor AHP. Where I = 1, …, n; j = 1, …, m.

Step 3. Find the positive ideal solution $A^+ = (v^*_1, \ldots, v^*_m)$, $v^*j = \max_i v_{ij}$, and the negative ideal solution $A^- = (v^-_1, \ldots, v^-_m)$, $vj- = \min_i v_{ij}$.

Step 4. Calculate the distance scale, that is, calculate the distance of each target to the positive ideal solution and the negative ideal solution. The distance scale can be calculated through Euclidean distance, and the distance function S_i is defined as:

$$S_i^+ = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2} \qquad S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2} \qquad (2)$$

Step 5. Arrange the priorities and calculate the closeness to the ideal solution CC_i, where $0 \leq CC_i \leq 1$. When $0 \leq CC_i \leq 1$ indicates that the target is the optimal target. When $CC_i = 1$ indicates that the target is the worst. In actual multi-objective decision-making, where:

$$CC_i = \frac{S_i^+}{S_i^- + S_i^+} \qquad (3)$$

TOPSIS and AHP are both multi-criteria decision-making (MCDM) methods. Both are often used in selecting and evaluating plans. Decision-makers can evaluate plans under several evaluation criteria [7].

4. Data analysis and results

4.1. AHP analysis results

The selection indicators at each level are distributed according to the relative importance ratio, which shows the importance of the key factor indicators at this level in the entire evaluation system, and generates the overall weight of the selection of PCRM design image preference factors, summarized in **Table 3**.

Table 3. Main factors of PCRM

Facets	Key Charisma Factor Indicators	Overall weight W_1
Social trend	Factor 1: The perceptual value of PCRM can form a new cultural aesthetic.	0.14716
	Factor 2: Ceramic mural artists should have quality, design, and high visibility.	0.05284
Technology survey	Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art.	0.1055
	Factor 4: Ceramic mural artisans with artistic backgrounds and knowledge of building construction can become ceramic mural masters.	0.0945
Economic approach	Factor 5: Promote lightweight ceramic mural artworks to integrate into the company's factories.	0.0536
	Factor 6: Public agencies take the lead in promoting large-scale ceramic mural art, which can benefit craftsmen and market internationally.	0.1464
Environmental issue	Factor 7: Universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance.	0.2
Political constraint	Factor 8. The cultural department revised the PCRM law to only allow top ceramic mural artisans to win the bid to ensure quality.	0.2

Based on **Figure 2**, the subordinate matrix W_2 can be obtained through the dependency properties of AHP, as shown in **Table 4**.

Table 4. Subordinate matrix W^2

W_2	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8
Factor1	0.663	0	0.663	0	0	0.659	0	0
Factor2	0	0.559	0	0	0	0	0.730	0.731
Factor3	0.195	0	0.195	0	0	0.185	0	0
Factor4	0	0.261	0	0.75	0	0	0	0
Factor5	0	0.133	0.142	0	1	0	0.188	0
Factor6	0.142	0	0	0.25	0	0.156	0	0.188
Factor7	0	0	0	0	0	0	0.082	0
Factor8	0	0.048	0	0	0	0	0	0.081

The real evaluation benchmark $W = W_2 * W_1$ were,

$$W_2 = \begin{bmatrix} 0.663 & 0 & 0.663 & 0 & 0 & 0.659 & 0 & 0 \\ 0 & 0.559 & 0 & 0 & 0 & 0 & 0.730 & 0.731 \\ 0.195 & 0 & 0.195 & 0 & 0 & 0.185 & 0 & 0 \\ 0 & 0.261 & 0 & 0.75 & 0 & 0 & 0 & 0 \\ 0 & 0.133 & 0.142 & 0 & 1 & 0 & 0.188 & 0 \\ 0.142 & 0 & 0 & 0.25 & 0 & 0.156 & 0 & 0.188 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.082 & 0 \\ 0 & 0.048 & 0 & 0 & 0 & 0 & 0 & 0.081 \end{bmatrix} \quad W_1 = \begin{bmatrix} 0.147 \\ 0.053 \\ 0.106 \\ 0.095 \\ 0.054 \\ 0.146 \\ 0.2 \\ 0.2 \end{bmatrix}$$

Therefore, through the AHP process, the real evaluation benchmarks for each key factor are shown in **Table 5**.

Table 5. PCRM preference factor real evaluation benchmark $W = W_2 * W_1$

Facets	Key Charisma Factor Indicators	Overall weight W_i	Facets
Social trend	Factor 1: The perceptual value of PCRM can form a new cultural aesthetic.	0.264	2
	Factor 2: Ceramic mural artists should have quality, design, and high visibility.	0.322	1
Technology survey	Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art.	0.076	6
	Factor 4: Ceramic mural artisans with artistic backgrounds and knowledge of building construction can become ceramic mural masters.	0.085	5
Economic approach	Factor 5: Promote lightweight ceramic mural artwork in the company's factories.	0.114	3
	Factor 6: Public agencies take the lead in promoting large-scale ceramic mural art, which can benefit craftsmen and market internationally.	0.105	4
Environmental issue	Factor 7: Universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance.	0.016	8
Political constraint	Factor 8: The cultural department revised the PCRM law to only allow top ceramic mural artisans to win the bid to ensure quality.	0.019	7

4.2. TOPSIS - IPA analysis results

There were 379 valid IPA questionnaires recovered. This study used SPSS.17 statistical software to conduct reliability analysis. After sorting the questionnaires, the Cronbach's Alpha value of the importance questionnaire was 0.839, and the Cronbach's Alpha value of the satisfaction questionnaire was 0.917. Both are greater than 0.7, which is a credible level. The IPA evaluation matrix is shown in **Table 6**.

Table 6. Evaluation matrix (r_{ij})

Factors	Importance	Performance
Factor 1: The perceptual value of PCRM can form a new cultural aesthetic.	4.329	4.372
Factor 2: Ceramic mural artists should have quality, design, and high visibility.	4.246	4.222
Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art.	4.237	4.179
Factor 4: Ceramic mural artisans with artistic backgrounds and knowledge of building construction can become ceramic mural masters.	4.28	4.285
Factor 5: Promote lightweight ceramic mural artwork in the company's factories.	4.159	4.043
Factor 6: Public agencies take the lead in promoting large-scale ceramic mural art, which can benefit craftsmen and market internationally.	4.319	4.203
Factor 7: Universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance.	4.275	4.14
Factor 8: The cultural department revised the PCRM law to only allow top ceramic mural artisans to win the bid to ensure quality.	3.87	3.792

The evaluation matrix of the Importance-Performance value of IPA weighted by the preference factor AHP weight is shown in Table 6, as shown in **Table 7**.

Table 7. Evaluation Matrix (v_{ij})

Key Factors	Importance	Performance
Factor 1: The perceptual value of PCRM can form a new cultural aesthetic.	1.143	1.154
Factor 2: Ceramic mural artists should have quality, design, and high visibility.	1.367	1.359
Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art.	0.322	0.318
Factor 4: Ceramic mural artisans with artistic backgrounds and knowledge of building construction can become ceramic mural masters.	0.364	0.364
Factor 5: Promote lightweight ceramic mural artwork in the company's factories.	0.474	0.461
Factor 6: Public agencies take the lead in promoting large-scale ceramic mural art, which can benefit craftsmen and market internationally.	0.453	0.441
Factor 7: Universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance.	0.068	0.066
Factor 8: The cultural department revised the PCRM law to only allow top ceramic mural artisans to win the bid to ensure quality.	0.074	0.072

From **Table 7**, the positive ideal solution A^+ = (1.376, 1.359) and the negative ideal solution A^- = (0.068, 0.066) are known according to the Importance-Performance value, and the distance from the preference factor to the positive ideal solution and negative ideal solution can be obtained, as shown in **Table 8**.

Table 8. Distance from preference factors to positive ideal solution and negative ideal solution

Factors	Distance to the positive ideal solution	Distance to the negative ideal solution
Factor 1	0.304	1.529
Factor 2	0	1.833
Factor 3	1.475	0.358
Factor 4	1.413	0.42

Table 1 (Continued)

Factors	Distance to the positive ideal solution	Distance to the negative ideal solution
Factor 5	1.266	0.566
Factor 6	1.295	0.537
Factor 7	1.833	0
Factor 8	1.824	0.008

As mentioned, the coefficient close to the negative ideal solution can be obtained, as shown in **Table 9**.

Table 9. Closeness to the positive ideal solution, CC_i

Factors	Proximity Coefficient	Sort
Factor 1	0.166	2
Factor 2	0	1
Factor 3	0.805	6
Factor 4	0.771	5
Factor 5	0.691	3
Factor 6	0.707	4
Factor 7	1	8
Factor 8	0.995	7

5. Conclusion

This study uses STEEP and AHP intrinsic qualitative methods to study key preference factors for PCRM in the Taiwan region. The following conclusions were obtained.

STEEP and AHP can indeed extract the important factors in the image of PCRM of the Taiwan region by experts and scholars, and then use the ideal solution similarity sequential preference method (TOPSIS) to rank the preference factors, which can infer the extraction and analysis of the core concepts of artistic creation.

From the analysis results in Sections 4.1 and 4.2, the Importance-Performance evaluation order is as follows. Factor 2: Ceramic mural artists should have quality, design, and high visibility; Factor 1: The perceptual value of PCRM can form a new cultural aesthetic; Factor 5: Promote lightweight ceramic mural artworks in the company's factories; Factor 6: Public agencies take the lead in promoting large-scale ceramic mural art, which can benefit craftsmen and market internationally; Factor 4: Ceramic mural artisans with artistic background and knowledge of building construction can become ceramic mural masters; Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art; Factor 8: The cultural department revised the PCRM law to only allow top ceramic mural artisans to win the bid to ensure quality; and Factor 7: Universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance. Through these structural analysis methods, this study hopes to break away from the established impressions and reflect the entire ethnic group's confidence in its own culture and the value of art, and then make good use of these images with deep cultural connotations in daily life environments or commercial applications. It also gives PCRM in the Taiwan region a more diversified presentation method, provides a reference basis and research methods for these images with in-depth cultural connotations, and further injects them into industrial creative design.

Disclosure statement

The authors declare no conflict of interest.

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