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Application of STEEP and Interpretive Structural Modeling in the Design Imagery of Taiwan Public Ceramic Relief Murals

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Abstract: Ceramic relief mural is a contemporary landscape art that is 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. Taiwan public ceramic relief murals (PCRM) are most distinctive with the PCRM pioneered by Pan-Hsiung Chu of Meinong Kiln in 1987. In addition to breaking through the limitations of traditional public ceramic murals, Chu leveraged local culture and sensibility. The theme of art gives PCRM its unique style and innovative value throughout the Taiwan region. This study mainly analyzes and understands the design image of public ceramic murals, taking Taiwan PCRM's design and creation as the scope, and applies STEEP analysis, that is, the social, technological, economic, ecological, and political-legal environments are analyzed as core factors; eight main important factors in the artistic design image of ceramic murals are evaluated. Then, interpretive structural modeling (ISM) is used to establish five levels, analyze the four main problems in the main core factor area and the four main target results in the affected factor area; and analyze the problem points and target points as well as their causal relationships. It is expected to sort out the relationship between these factors, obtain the hierarchical relationship of each factor, and provide a reference basis and research methods.

Keywords: Interpretive structural modeling (ISM); STEEP analysis; Public ceramic relief murals (PCRM)

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1. Introduction

Ceramic art in the Taiwan region is divided into pottery art, porcelain art, ceramics art, public ceramic relief murals (PCRM), etc., which is a kind of artistic charm aesthetics. The art of ceramic relief murals is carefully designed based on human nature, culture, and architectural space, combined with social customs and visual perceptual art. It is a kind of contemporary landscape art. Ceramic relief murals may also become the main axis of ceramic art in the future. Public art is designed based on the living environment and spatial vision combined

with theme art; the fusion of the two is public ceramic relief murals (PCRM), which have been popular in the Taiwan region for about 40 years. The main purpose of this study is to find out the core factors of the art of ceramic relief murals in the Taiwan region, understand the unique style and novel creativity of ceramic murals, promote the value of Taiwan PCRM, explore inheritance factors, and advocate the relationship between Taiwan ceramic art and the West sculpture aesthetics and ceramic wall public art. It is hoped that Taiwan PCRM aesthetics will move towards emerging design art, promote Taiwan ceramic art, give high artistic economic value, and provide references for customized design factors, giving commercial value without losing the elegance of artistic aesthetics and the inheritance of local cultural significance. Through in-depth interviews and STEEP analysis, the core factors are analyzed through the Social, Technological, Economic, Ecological, and Political-legal environments; then, the interpretive structural modeling (ISM) is used to establish five levels, analyze the four main problems in the main core factor area and the four main target results in the affected factor area; the complex factors relationships are sorted out to find out the hierarchical relationships of each factor, obtain the causes and results of the interrelationships between factors, and lastly analyze the causal relationships of each factor, and identify the corresponding problems and goals, and complete the goals and directions of effective planning.

2. Literature review

Taiwan ceramic art can be divided into three stages. In China, pottery art and ceramics art have been developed since ancient times; thus, Chinese ceramics art has a profound influence on that of the Taiwan region. The same goes for Japanese ceramics art during the Japanese occupation period. When the Taiwan region's economy took off, it was a period of glory for ceramic art, with exquisite and perfect craftsmanship. In the past 40 years, with the rise of heavy-duty PCRM, various ceramic wall works have flourished. Western art focuses on the charming thinking of the original creator, and European and American aesthetics attach great importance to public murals. Ceramic relief mural is an important indicator of the development of the ceramic industry. In religious temple buildings, artists express beliefs, religious stories, and images of gods through mural art to enrich people's spiritual experience. Mural art is popular, especially statues of gods, sculptures, and murals in religious temple buildings. Pan-Hsiung Chu [1] believed that ceramic murals appeared in Japan as early as 1956 in the old Tokyo Metropolitan Government Building designed by architect Tange Kenzo. This is an important stage in the development history of ceramic murals in the transformation of architectural thinking and its integration into artistic works. Chu-Chieh Hsiao [2] believed that Chinese ceramics were based on the monarchy in ancient times, and official kilns were the mainstream of the development of ceramic history, so many fine products have been handed down. During the Tang and Song Dynasties, China's ceramic craftsmanship reached a significant peak, and the Eight Famous Kilns were one of the most famous ceramic production areas at that time. With its unique technology and style, it has won high praise internationally and its representative works include light bluish-green, oil droplets, black gold glaze, etc. Beijing Nine-Dragon Wall is a famous representative of Ming Dynasty architecture. It shows the rich level of ceramic murals and has become a Chinese treasure in art. Regarding the origin of early Taiwan ceramic art, Chu-Chieh Hsiao believed that it was the inheritance of Chinese culture and retained a strong cultural heritage. The development of Taiwan ceramics can be traced back to the 1970s, when economic and information development took off in the 1960s. Foreign cultures were introduced, bringing excitement and awakening, and finally integrated and transformed into the Taiwan region's local culture. Professor Pao-Chia Lin was the first ceramic artist to study in Japan. After returning to the Taiwan region, he devoted himself to the research and teaching of ceramics and established the Tao Lin Ceramics Classroom. He

is known as the “Father of Taiwan Ceramics.” The development of Taiwan ceramic art is due to the inheritance of traditional Chinese techniques and the introduction of Japanese technology. The younger generation of ceramic artists has begun to create ceramic walls one after another, and Taiwan ceramic mural works are also becoming more and more mature. The creation of ceramic murals is no longer limited to a limited square inch. With the infinite extension of the building wall and the many possibilities for creation, ceramics also form a creative stage for free expression.

After 1980, Pan-Hsiung Chu upgraded the application theme design of Taiwan ceramic art into the driving force of PCRM and was the most powerful founder and promoter. To this day, some ceramic artists have conducted in-depth research and it has become a trend. Ceramic relief mural works can be found in schools, public institutions, private factories, and companies across the Taiwan region. Ceramic mural is full of challenges and innovations. Craftsmen can use their own abilities to create designs, which can also become customized and commercialized ceramic relief mural art.

In 1980, Pan-Hsiung Chu studied industrial ceramics under Professor Yu-Tang Wu. He is also the only person in the Taiwan region who used his thesis “Pan-Hsiung Chu’s Ceramic Wall Public Art” to obtain a doctorate in art from Griffith University in Australia. Thus, many Australian university art scholars have formulated a special English vocabulary for public ceramic relief mural art (PCRM), which has also become the proper noun for “Public Ceramic Mural Art” of Meinong Kiln. This study hopes to use an explanatory structural model to analyze the causal relationship between various factors. Explanatory structural models are widely used in various fields, for example, Ming-Tang Wang and others [3] applied the interpretive structural model (ISM) to build innovation that integrates new product development. Ming-Tang Wang [4] also recognized the main goals of using ISM to solve rescue-related problems in harsh terrain or landslides. This study hopes to understand the corresponding problems and goals by sorting out the causal relationships and hierarchical relationships of the image factors of PCRM design, complete the goals and directions of effective planning, and provide a reference basis and research method [5-10].

3. Research design and methods

This study used in-depth interviews in the five major aspects of STEEP and proposed eight issues related to the art of ceramic relief murals and a total of 40 factors. Experts were asked to score in order, and those with the highest scores entered the causal correlation analysis. The interpretive structural modeling (ISM) method was used to observe the correlation between elements, and then obtain the main topics and main goals of the factors. In this way, the reference basis for the development of public ceramic relief murals is discussed to enhance the public’s understanding and feelings of PCRM culture.

3.1. STEEP analysis

Through the analysis of the five aspects of the environment: Social, Technological, Economic, Ecological, and Political-legal, the overall environment can be judged. From the development and changes of these environments, we can foresee and judge the opportunities and threats that market development brings to enterprises, and provide a strong basis for further development. This study used STEEP to analyze the five aspects and sorted out 40 related factors as follows.

(1) Social trend factors: The beauty and perceptual artistic value of PCRM can form a new cultural aesthetic. The character and reputation of ceramic mural artists are crucial to the acceptance and market value of the artwork. At the same time, the inheritance from master to apprentice helps to protect and develop the traditional skills of ceramic mural art. It not only retains a rich cultural heritage but also

contributes to spiritual education, cultural inheritance, and the spread of social values.

(2) Technology survey factors: The advancement of ceramic mural glaze kiln firing technology and digital design, experienced kiln firing craftsmen with profound backgrounds, diversified perceptual creativity, participation of young digital designers, the popularization of mural art education courses in community colleges, etc., are promoting the upgrading and renewal of the ceramic mural industry.

(3) Economic approach: Due to economic factors, Meinong Kiln promotes lightweight ceramic mural sales products and goes deep into companies, factories, and tourist attractions as trademark advertising sites. In addition, ceramic mural art is also durable and reduces maintenance costs. Public agencies have taken the lead in promoting ceramic mural art, benefiting craftsmen and marketing it internationally. At the same time, temples can also use painted designs to present PCRM, and the ceramic teams and pottery craftsmen will gain more income, and they will concentrate on creation.

(4) Environmental issue: This includes the selection of installation locations, the application of school education, the artistic design of ceramic murals for community landmarks, the establishment of relevant courses in universities, the corporate management of ceramic murals, the theme design of ceramic murals for factories and B&Bs (bed and breakfasts), etc. Considering the topic, PCRM can be better integrated into social life, improve its popularity and influence among the public, and at the same time promote the application and development of PCRM in different fields.

(5) Political constraint factors: Political constraints have a very important impact on PCRM. The following are some relevant viewpoints. Importing clay and pigments, and transnational procurement of raw materials have become a trend. Consumer protection laws, political stability, the expansion of the Chinese world, and government assistance in internationalization promote the competitiveness of ceramic mural art in the international market. The government can promote creative design capabilities by issuing certificates and awards to folk craftsmen, and ensure quality through the revision of regulations by the Ministry of Culture. Overall, political constraints play an important role in the internationalization, production, and quality assurance of ceramic mural art. Government support and the formulation of corresponding policies will help promote the development and improvement of the PCRM industry.

3.2. Interpretive structural modeling (ISM)

Interpretive structural modeling (ISM) is a mathematical analysis model proposed and developed by Warfield in 1973 [6,11-14]; it is a branch of Graph Theory. The ISM program is based on the correspondence mechanism between a binary matrix and a directed graph. The basic concepts of the program are “element set” and “transition relationship.” The main purpose is to convert complex element relationships into associated structures; to sort out various logical structural relationships and to find out the hierarchical relationships of each factor.

Malone [15] showed that via the adjacency matrix, it can be proven that by adding the identity matrix and then raising the resulting matrix to successive powers until no new entries are obtained; the reachability matrix can be obtained operationally from the adjacency matrix, the causal relationship diagram of each factor can be obtained. In addition to providing scientific methods to structure complex systems, ISM also provides a solution to the problem of sorting relationships between elements. In practice, it is mostly used to solve design, manufacturing, and quality control problems. In terms of the implementation steps of this study, experts established a causal relationship table of eight factors, obtained the adjacency matrix A and the reachability matrix M, and then established a hierarchical structure model relationship analysis diagram. The logical operation rules of Boolean for matrix operations are shown in **Table 1**.

Table 1. Boolean algebraic algorithm (Boolean)

Addition algorithm	Multiplication algorithm
$0 \oplus 0 = 0$	$0 \otimes 0 = 0$
$1 \oplus 0 = 1$	$1 \otimes 0 = 0$
$0 \oplus 1 = 1$	$0 \otimes 1 = 0$
$1 \oplus 1 = 1$	$1 \otimes 1 = 1$

4. Data analysis and results

4.1. Relationship between constructs and factors

From the STEEP analysis above, experts analyzed and evaluated again and further concluded that the eight main factors of PCRM are as follows (**Table 2**).

Table 2. Eight main factors of PCRM

STEEP	Factors
Social trend	Factor 1: The perceptual value of PCRM can form a new cultural aesthetic. Factor 2: Ceramic mural artists should have quality, design, and high visibility.
Technology survey	Factor 3: The advancement of digital technology design is conducive to the development of ceramic mural art. Factor 4: Ceramic mural artisans with artistic backgrounds and knowledge of building construction can become ceramic mural masters.
Economic approach	Factor 5: Promotion of lightweight ceramic mural art works to penetrate into 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.
Environmental issue	Factor 7: Universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance.
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.

4.2. The cause-effect relational table between factors

The correlation between factors 1 to 8 was analyzed and evaluated by experts. Among them, 1 means that the two factors are related, and 0 means that the two factors have no relationship, and a causal relationship table is obtained (**Table 3**).

Table 3. The cause-effect relational list

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Factor 1	0	0	1	0	0	1	0	0
Factor 2	0	0	0	0	0	0	1	1
Factor 3	1	0	0	0	0	1	0	0
Factor 4	0	1	0	0	0	0	0	0
Factor 5	0	1	1	0	0	0	1	0
Factor 6	1	0	0	1	0	0	0	1
Factor 7	0	0	0	0	0	0	0	0
Factor 8	0	1	0	0	0	0	0	0

From **Table 3**, we can let A be the adjacency matrix, $B = A + I$, and I be the identity matrix.

Then, we have

$$A = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad B = A + I = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}.$$

From the matrix B, we obtain the reachability matrix $M = B^5$, and

$$M = \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \end{bmatrix}.$$

4.3. Creating a multilevel structural hierarchy

Let A_i be the i-th factor item, and then the set $R(A_i)$ is the collection of elements containing 1 of columns in the corresponding row of the reachability matrix M called Reachability Set. In the corresponding row of the transpose reachability matrix M^T, the set $Q(A_i)$ is the collection of elements containing 1 of columns in the matrix M^T called Priority Set.

4.3.1. Creating the first level of the hierarchy diagram

The Reachability Set, Priority Set and their intersection relationship between factors can be established from the reachable matrix M (**Table 4**). Because of $R(A_i) = R(A_i) \cap Q(A_i) = \{7\}$, the first level is Factor 7.

Table 4. The Reachability Set, Priority Set, and their intersection relationship

Factors	$R(A_i)$	$Q(A_i)$	$R(A_i) \cap Q(A_i)$
1	1234678	1356	136
2	278	1234568	28
3	1234678	1356	136
4	2478	13456	4
5	12345678	5	5
6	1234678	1356	136
7	7	12345678	7
8	278	1234568	28

4.3.2. Creating the second level of the hierarchy diagram

Table 5 can be obtained by removing Row 7 from **Table 4** and deleting Factor 7 in the row elements in **Table 4**. From **Table 5**, because $R(A_i) = R(A_i) \cap Q(A_i) = \{2,8\}$, the second level is factor 2 and factor 8.

Table 5. Creating the second level of the hierarchy diagram

Factors	$R(A_i)$	$Q(A_i)$	$R(A_i) \cap Q(A_i)$
1	123468	1356	136
2	28	1234568	28
3	123468	1356	136
4	248	13456	4
5	1234568	5	5
6	123468	1356	136
8	28	1234568	28

4.3.3. Creating the third level of the hierarchy diagram

Table 6 can be obtained by removing Row 2 and Row 8 from **Table 5**, and deleting Factor 2 and Factor 8 from the row elements in **Table 6**. From **Table 6**, because of $R(A_i) = R(A_i) \cap Q(A_i) = \{4\}$, the third level is Factor 4.

Table 6. Creating the third level of the hierarchy diagram

Factors	$R(A_i)$	$Q(A_i)$	$R(A_i) \cap Q(A_i)$
1	1346	1356	136
3	1346	1356	136
4	4	13456	4
5	13456	5	5
6	1346	1356	136

4.3.4. Creating the fourth level of the hierarchy diagram

Table 7 can be obtained by removing Row 4 from **Table 6** and deleting Factor 4 from the row elements in **Table 6**. From **Table 7**, because of $R(A_i) = R(A_i) \cap Q(A_i) = \{1, 3, 6\}$, the fourth level is Factors 1, 3, 6.

Table 7. Creating the fourth level of the hierarchy diagram

Factors	$R(A_i)$	$Q(A_i)$	$R(A_i) \cap Q(A_i)$
1	136	1356	136
3	136	1356	136
5	1356	5	5
6	136	1356	136

4.3.5. Creating the fifth level of the hierarchy diagram

Table 8 can be obtained by removing Rows 1, 3, and 6 from **Table 7** and deleting Factors 1, 3, and 6 in the row elements in **Table 7**. It can be seen from **Table 8** that the fifth level is Factor 5. Overall, the hierarchical network relationship can be drawn as shown in **Figure 1**.

Table 8. Creating the fifth level of the hierarchy diagram

Factors	$R(A_i)$	$Q(A_i)$	$R(A_i) \cap Q(A_i)$
5	1356	5	5

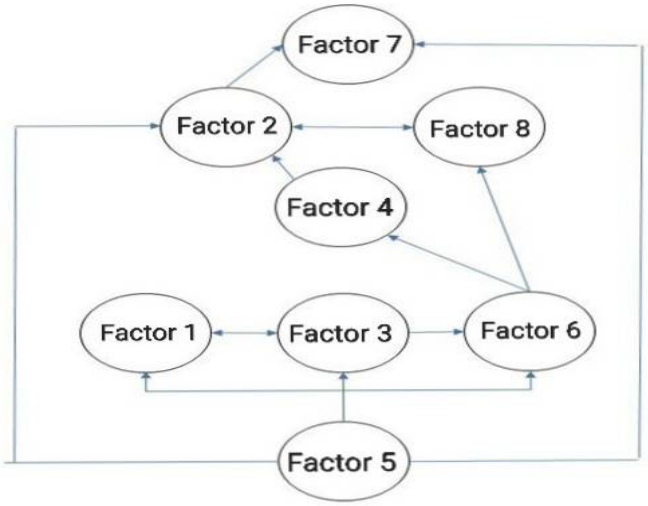

Figure 1. Network diagram of factors and causes

The ISM Interpretive Construction Model Method simplifies complex causal relationships, explains the causes and consequences of the relationship, and finally analyzes the causal relationships of each factor to understand the corresponding problems and goals and complete the goals and directions of effective planning. Among them, the D_i value refers to the degree to which a single factor affects other factors, that is, the sum of the numbers in the i-th column of the reachable matrix. When the D_i value is larger, it means that the factor has a greater impact on other factors. R_i value refers to the degree to which a single factor is affected by other factors, that is, each number in the i-th row of the accessible matrix; and the larger the R_i value, the greater the degree to which this factor is affected by other factors.

(1) Cause degree: $D_i - R_i$ refers to the degree to which a single factor affects other factors.

(2) Core degree: $D_i + R_i$ refers to the importance of a single factor compared to other factors.

(3) Cause factors: Cause factors refer to factors whose cause degree ($D_i - R_i$) is greater than 1. These factors have more influence on other factors, so they are the factors that need to be considered first.

(4) Result factors: Result factors refer to factors whose cause degree ($D_i - R_i$) is less than 1. These factors are more affected by other factors, so they are the results that will be achieved after taking the cause factors into consideration.

(5) Core factors: The core degree value refers to the factor with the largest core degree ($D_i + R_i$), which is the most important factor among all factors. The values of core factors, cause factors, and result factors of each factor are shown in **Table 9**.

Table 9. The values of core factors, cause factors, and result factors of each factor

	D_i	R_i	$D_i + R_i$	$D_i - R_i$
Factor 1	7	4	11	3
Factor 2	3	7	10	-4
Factor 3	7	4	11	3
Factor 4	4	5	9	-1
Factor 5	8	1	9	7
Factor 6	7	4	11	3
Factor 7	1	8	9	-7
Factor 8	3	7	10	-4

The meaning of the quadrant of its numerical value is shown in **Figure 2**. The cause-effect diagram (**Figure 3**) can clarify factors as "Cause Factors," "Result Factors," or "Core Factors." The vertical axis is the "Cause Degree" and the horizontal axis is the "Core Degree." The factors that appear in the upper half of the cause-and-effect diagram are "Cause Factors," and the factors in the lower half are "Result Factors." The closer a factor is to the right of the number line, the greater the centrality; the greater the influence and influence of this factor in the factor set.

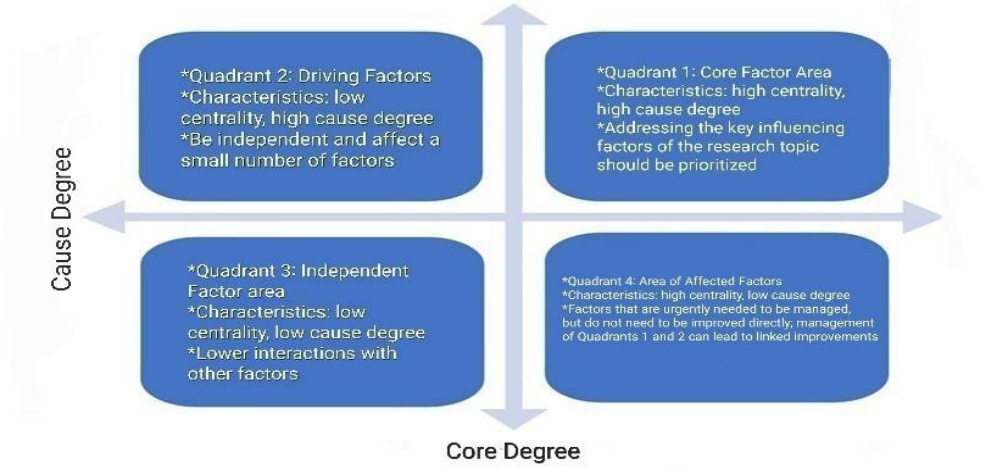

Figure 2. The meaning of the quadrant of the numerical values

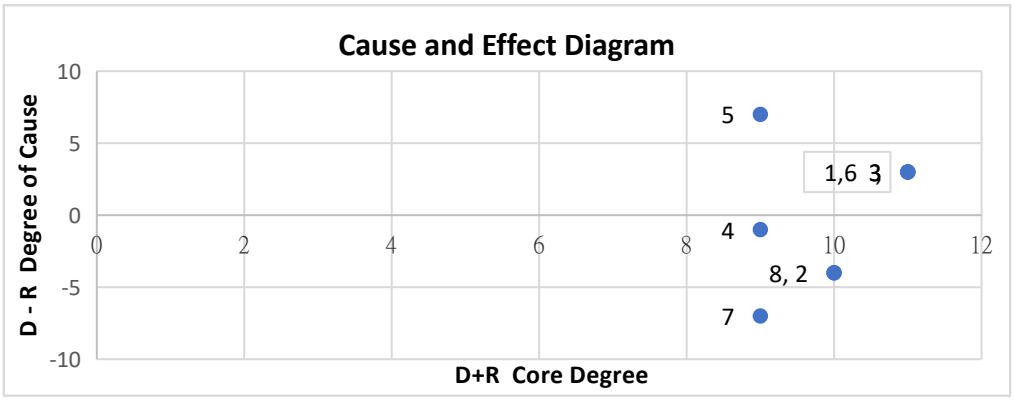

Figure 3. Cause and effect diagram

4.4. Analysis of main issues and main goals

According to **Figure 3**, Factors 1, 6, 5, and 3 are in the main core factor area. When used as main issues, they are regarded as the starting point for exploring the causes of PCRM. When they are major questions, they are considered a starting point for exploring the causes of PCRM. Factor 1 is the perceptual charm value of PCRM, forming Taiwan region's new cultural aesthetics; Factor 6 is the policy-led promotion of large-scale ceramic mural art, which is conducive to marketing; Factor 5 is the promotion of lightweight ceramic mural art works to penetrate into private institutions, and Factor 3 is digital innovation advances in design and technical engineering conducive to the development of ceramic wall technology. Factors 4, 2, 8, and 7 are located within the affected factor area. As a result of the main goals, they are the core values pursued by the engineering and living aesthetics of ceramic mural art. Therefore, as long as the four main problems can be completed, the four main goals can be achieved, and they can be used as a reference and goal for the ceramic mural art and culture design style. We can further observe that Factor 5 and Factor 6 are the main node factors. From the network diagram of factor cause and effect in **Figure 1**, **Figures 4** and **5** can be obtained; it can be seen that if Factor 5 is completed to promote lightweight ceramic mural art and go deep into the company's factory, that is, to communicate with the industry, Factor 7 (universities offer courses related to ceramic wall design to cultivate talents, which is beneficial to employment and inheritance) and Factor 2 (ceramic wall artists should have moral character, design, and high visibility) can be achieved. At the same time, because Factor 2 has been completed, Factor 8 (the cultural department has revised the law on PCRM, allowing only top pottery wall masters to win the bid to ensure quality) has also been achieved. From **Figure 5**, if factor 6 is completed, target factors 2, 4, 7, and 8 can also be achieved.

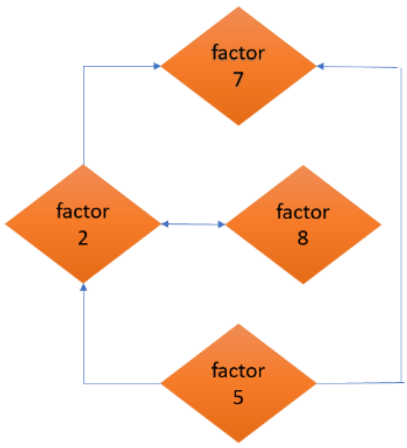

Figure 4. Cause and effect diagram of Factors 2, 5, 7, and 8

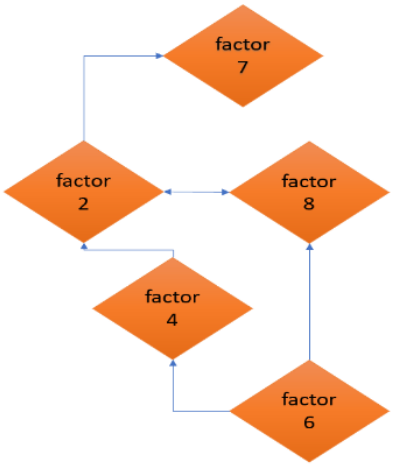

Figure 5. Cause and effect diagram of Factors 2, 4, 6, 7, and 8

5. Conclusion

This study used the STEEP and ISM methods to analyze the 40-factor items, re-evaluate the main eight important factors through experts, and analyze their problem points, target points, and their causal relationships. According to the core degree and cause degree coordinate diagram (**Figure 3**), it can be seen that Factors 1, 6, 5, and 3 are in the main core factor area, as the main original problem, that is, the starting point of the discussion of the cause of ceramic mural art. Factor 1 is the perceptual and charming value of PCRM, forming the Taiwan region's new cultural aesthetics. Factor 6 is that policy leaders promote large-scale ceramic mural art, which is beneficial to marketing. Factor 5 is the promotion of lightweight ceramic mural art works to penetrate

private institutions. Factor 3 is the advancement of digital innovative design and technological engineering is conducive to the development of ceramic mural techniques. Factors 4, 2, 8, and 7 are shown as the affected factor area in the core degree and cause degree coordinate diagram, which is the main goal and the core value pursued by the engineering and life aesthetics of ceramic mural art. At the same time, Factor 5 and Factor 6 are also obtained from cause-and-effect **Figure 1**, which are the main node cause factors. Therefore, as long as the node cause factors can be completed, the four main goals can be achieved. This study hopes to give artists who are craftsmen of PCRM a reference direction and a research method for solutions and improvements.

Disclosure statement

The authors declare no conflict of interest.

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