


Article

Research on the Design of Community Museums Based on the Fuzzy Comprehensive Evaluation Method

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Abstract: The new museum movement of the twentieth century has driven the development of the form and function of museums around the world. Museums began to be actively open to the public, and some new concepts of museums, such as eco-museums and community museums, emerged. The aim of these museums is to build a cultural bridge between people and the city and to promote the harmonious development of society, economy, and culture. The visitors, as the service targets of the museum, will directly influence the popularity of the museum among the masses by their evaluation of the museum experience; however, at present, there is a clear gap between the design of many museums and the feedback of subsequent visitors' experiences. Only by understanding visitors' feelings and preferences can subsequent museum design be improved; this paper will focus on demonstrating the application of the mathematical idea of the fuzzy comprehensive evaluation method to community museums; it establishes a community museum quality evaluation system based on human-centered design principles from the perspective of urban community museums and constructs a fuzzy comprehensive evaluation model of a community museum experience. Finally, the design of a community museum in Nottingham, UK, is used as an example to make a comprehensive evaluation of its quality. According to the analysis, the fuzzy comprehensive evaluation method has practical value in scientifically evaluating the quality of urban community museums through data on the visitor experience.

Keywords: urban regeneration; community museum; urban public space; fuzzy comprehension evaluation method



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1. Introduction

Traditionally, the public space could be identified by squares, major streets, theatres, restaurants, lecture halls, government assemblies, or stock exchanges where strangers would be likely to meet [1]. The public space exists in multiple forms in cities and is used in various ways [2]. The New Museum movement has expanded the meaning of museums [3]. The traditional temple form and the museum's majestic image have been upset and replaced by the weakened boundary and rich function of the museum space [4]. The International Council of Museums (ICOM) asks museums to shift their objective from transmitting expert knowledge to fostering dialogue and connection, which emphasizes museums' democratization and inclusiveness [5]. At present, the design of museums has shifted from the single point of view of urban planning and architecture to more complex fields. Integrating sociology, psychology, human culture, ecology, and other different fields to explain the meaning of public cultural facilities. Museums have been transformed from their initial privatization into urban public spaces, and they have become important public spaces in the city [6].

As an urban public cultural facility, museums are important parts of the whole city, which play important roles in perfecting urban functions, shaping urban image, improving

urban environmental quality, and inheriting history and culture [7]. With the continuous development of the city's economy, the improvement of people's living standards, and people's aspirations and cultural needs are also increasing. Museums have qualities that distinguish them from other urban public spaces. The museum delivers knowledge and inspiration to its visitors through displaying presentations and visual narratives as carriers of culture or historical artifacts, which have become one of the most popular public cultural spaces in the city. In terms of cultural education and transmission to the public, the development of museums has become one of the focuses of urban construction [8–10].

Museums are constantly evolving places and will offer even more possibilities to the public in the future. Every attempt must be made to expand the scope of the museum's providing activities [11]. Under the general concept of museums, there are also various branches and types of museums with different emphases, for example, national museums that are national treasures of the world, abstract and artistic art galleries, eco-museums that emphasize in situ conservation of the original, and community museums that are integrated into the life of the community, to name but a few; this research will focus on the branch of community museums. Most community museums are small, "hidden" in residential communities [12]. Sometimes a community museum acts as a community activity center, providing cultural exchange and services to the people of the community. The vitality of the community museum will reflect the cultural vitality of the whole community; it is a cultural platform for the public; this platform has the nature of a museum for knowledge, education, cultural preservation, cultural dissemination, and transmission; at the same time, it has the nature of a public space for the community, providing a place for daily activities and social interaction. As such, the community museum will be an important cultural arm of the urban public space, carrying the significance of cultural spreading and transmission to the public.

To make community museums a part of residents' lives, then, it is necessary to provide them with a satisfying experience. Most museums pay attention to the spatial context of animation scene narration and propose to design a "talking" scene to present a good narrative effect, that is, when the character does not appear in the picture, the audience should feel the visual information of the scene as soon as they see a scene picture and associate it with the appearance of the scene and its relationship with the character [13]. While these innovations in exhibitions are important, as community museums, we need to think more broadly about the experiences and feeling that a community public space brings to its users. In general, a community museum is a combination of a museum and a community venue, more like a culturally contextualized community space where users will engage in culturally based activities and socializing.

The basic principle of the fuzzy comprehensive evaluation method is to break down an evaluation problem into multiple sub-items; after that, score each sub-item; and finally, calculate the result of the original evaluation problem based on the combined weight of each sub-item. Since these indicators are often fuzzy in nature, which can be found in the process of transforming from qualitative to quantitative, this comprehensive evaluation is fuzzy comprehensive evaluation [14]. In the field of architecture or urban planning, often the evaluation of a place that is good or bad is influenced by several factors, which helps to break down the evaluation problem naturally. Currently, the application of fuzzy comprehensive evaluation methods is still in the experimental stage, and some scholars have demonstrated evaluation research of buildings, such as in the fields of quality assessment of green buildings, industrial buildings evaluation, and residential satisfaction [15–18]; however, there is still a gap in the evaluation of museum space. The museum is an important public cultural place serving the city, so the public's demand and evaluation of it are very important. Architectural design is not only subjective and technically applied by the architect, but also about the need for user participation and constant feedback. Evaluating public buildings from the public's perspective (as well as the user's perspective) is an important way to truly reflect the success of a project. Because public preferences vary, evaluating public buildings must take into account all aspects

and requires the selection of multiple evaluation indicators, which is a comprehensive evaluation. Since the public is not an expert, it is difficult to give professional and in-depth opinions during the evaluation process. Therefore, this study first breaks down the evaluation items through scholars in related fields, asks questions to the public in a simple and clear manner, and receives feedback. The feedback from these subitems is then scientifically organized and statistically analyzed to obtain a comprehensive evaluation of the quality of community museums.

This study will mainly illustrate and demonstrate the application of the fuzzy comprehensive evaluation method in architecture and urban planning, using real projects as examples. The article will firstly define and analyze community museums as important urban public cultural facilities, and develop a relevant evaluation model through its characteristics; secondly, apply this evaluation model to the selected case, The New Art Exchange, Nottingham, UK, and obtain the public feedback data; then, conduct a fuzzy comprehensive evaluation and calculation of the data; the evaluation of the museum, as reflected in the calculations, is analyzed and comments for future development are made; this research makes a systematic analysis of its tourists' experiences and feelings, to create conditions for promoting the better development of community museums, and to a certain extent, provides a reference for the development of other urban cultural public facilities.

2. Community Museums

The 1960s and 1970s were turbulent periods in the history of the world. Many previously colonized countries, mainly in Africa, began to gain independence; and people of African, Latin American, and Indian descent in North America began to struggle for equal rights. Driven by this historical context, more and more people of color and minorities are exploring the history and roots of their own race, and there is a new interest in traditional ethnic culture and historical heritage [19]. Museums, as vehicles for embracing multiple cultures, have subsequently ushered in new historical changes. The term *écomusée* was first introduced in 1971 by Georges Henri Rivière, the founder of modern French museology, and Hugues De Varine, a French museologist [20]; they advocated the use of ecological methods to bring exhibits to life in their native environment, thus triggering a social search for the idea of creating a living museum. The concept of eco-museums has since spread from Europe to other parts of the world, and their names have changed from place to place. Kenneth Hudson, a leading American museum scholar, introduced the concept of community museums based on the idea of eco-museums. In his book *Museums of Influence*, he introduces the Anacostia Community Museum, a museum located in the black community of Washington, D.C., which Hudson describes as "the black church version of the museum in America" [21]. Community museums focus on neighborhoods, the areas where people live their daily lives, and focus on specific areas and groups of people to record and present history and culture in a more detailed and thematic way that is relevant to them and aim to adapt to the actual needs of the community and encourage people to interact culturally and socially [22]. In the twenty-first century, the future success of museums depends on identifying and meeting visitors' needs, which could put the visitors in a very central position to consider [23]. More and more museums are actively opening their doors while seriously thinking about their characteristics and positioning to create a better experience and communication for their visitors.

Museums now need to focus not only on increasing the number of visitors but also on how to attract more repeat visitors by opening up to a variety of people from all angles, such as those from different cultural, religious, ethnic, and educational backgrounds. In reality, however, visitors have different needs, and it is difficult for designers to satisfy everyone's preferences in the design process. The problem may be much easier if designers can determine the impact of the museum space environment on the visitor experience through a specific comprehensive assessment system; this would require an assessment system that specifically addresses the quality of community museums. A good museum space should be fully used while providing a good experience for the user [24]. Therefore, in the

evaluation of the quality of community museums, the feelings and cognitive processes of the users should be carefully considered so that people can gain knowledge and enjoyable feelings during the step-by-step process.

3. User's Experience and the Quality of Community Museums

3.1. *Shaping of Experience in Community Museums*

Since the 20th century, driven by the trend of late modern philosophy, people begin to affirm life and respect life's value and significance [25–27]. The discussion on the relationship between the subject's perception and the external environment on experience has never stopped. Individuals' perception of the environment is the critical process of forming the experience. The concept of "experience" in the dictionary is that the practical things that occur and affect people's feelings may leave an impression [28,29]; it is people's actual personal contact and observation of facts or events around them through their bodies. In today's people-oriented society, the importance of experience is emphasized from urban development to architectural design; it can be said that experience is one of the most important criteria for measuring the popularity of architectural space.

As an important public space in the city, the community museum delivers not only cultural information to the public in the form of exhibits, but also the cultural experience and social atmosphere that the whole building brings. The architectural space can influence the visitor's experience through various forms, scales, and cultural content presented within. The intermediary from form to meaning is the person who uses and experiences the building as a cultural building [30]. Any architectural form or exhibition decoration can only have a specific meaning if it works and affects people, which involves the processes and characteristics that shape people's experiences [31]. People can experience feelings without first invoking concepts; their bodily awareness of the senses of a situation first allows people to begin to make meaning of it [32]. Thus, the body acts as a medium that connects the human experience to the environment. People who visit cultural facilities are constantly stimulated by their environment, such as space, light, sound, etc. Sometimes, visitors can recognize or become aware of these stimuli, which may be directly related to their memories and experiences and are limited by subjective consciousness and cognitive characteristics [33]. Sometimes visitors react to their situation through neurotic instincts and subconsciousness, which does not require brain analysis. Both conscious and unconscious experiences always appear together and into a complete visiting experience [33,34]. In addition, the visitor's cognitive abilities are shaped by the interaction with the environment [35]. When a stimulus appears, the sensory system detects it, then stores and transforms it into memory, and finally responds to it. Through visiting, learning, playing, and other activities in cultural facilities, people acquire and communicate information that is consistent with their cognitive processes [36]. Human cognition is a series of mental processes in which information is absorbed through sensory organs, then understood, processed, stored, and reused through several cognitive structural units, and then the resulting information is used to solve practical problems [37]. Thus, the experience that community museums should provide for visits is a process that enables visitors to engage with the space in a continuous and conscious cognitive manner. Visitors generate different experiences of their visit and use through their bodily perception of different community museum building environments.

"Experience" is emerging as a significant source of value-added to contemporary cultural production. In this case, it is not an abstract or a theoretical concern; rather, it refers to well-designed means for attracting cultural consumers by catering to users' needs in a stimulating environment of sought-after memorable events. People's experiences are based on a series of events, including historical memories, present perceptions, and future expectations [30,31]. There is an intimate relationship between people's emotions and their surroundings [38]. Architecture can be perceived through details, materials, spaces, and other elements. Memory, time, and space together can determine the architectural experience [39]. The natural environment in the city, the surrounding architectural style

and scale, the architectural features, volume and spatial layout of the cultural facilities themselves, etc., all form different impressions in the minds of the public, and as their participation in the cultural facilities varies, a variety of events and activities will occur in the spaces of the cultural facilities, which will also prompt different behaviors from the users, resulting in a more profound experience. The user's experience of public cultural facilities is composed of various interactive visual things and events in the urban environment. The elements constituting the users' experience can be summarized as follows: natural elements (e.g., natural environment), artificial elements (e.g., buildings and layouts), and event elements (e.g., activities); it is essential to note that it is difficult for a cultural building to satisfy everyone with all of these elements, and also that these elements have different impacts on different people, which means that there may be differences in the weighting of the elements. For example, some people care a lot about the cultural building's echoing and protection of the natural environment, while others are more concerned about the use of the cultural building's internal functions and the convenience of transportation, etc.

In the new social patterns, people challenge traditions, criticize the past, and are more eager to escape the shackles of their environment. Especially in an increasingly anonymous online society, interpersonal relationships have become more isolated and utilitarian. The ultimate goal of adhering to the concept of human-centered design is to meet the psychological and physical expectations of users and make them feel a positive atmosphere; this is the necessary condition that a good space design should satisfy. Especially in the context of pandemics in recent years, people need to keep social distancing in public places to prevent the spread of viruses. Places that were lively and prosperous have become cold and quiet. For public cultural facilities such as parks, squares, museums, and libraries, rational design and careful arrangement can still create a welcoming experience for passersby; it is more important to rely on creating a positive experience to stimulate a positive attitude and enthusiasm for life so that users can experience both physical and psychological environment comfort; however, since people have different preferences and cognitive abilities while advocating a human-centered design concept, it is necessary to truly understand and empathize with the public from the user's perspective. Focusing on the cultural building and verifying whether the space is welcomed by visitors is a key issue encountered in the design of cultural facilities. For designers, it is important to get feedback from users, learn the advantages and avoid the disadvantages, and apply them to future designs to make the building evolve and update. Therefore, there is a great need to establish a system of criteria to assess the quality of public cultural facilities.

3.2. Assessment System for the Quality of Community Museums

It is well-known within an architectural practice that a building's worth can be measured by its ability to accommodate its intended use and by knowing about the users who have the most direct and extensive relationship with building use [40]. A community museum has already become a diverse urban public space, and it is now a culturally based free social place in the city. Each public cultural building carries a different set of requirements; thus, human needs must be understood and studied within the framework of each design problem. In space, the functions, circulation, physical environment, scale, aesthetic value, and so on, can influence people's experience when they arrive at the cultural space and may affect their subsequent viewing experience. A good experience of the cultural space should make users feel comfortable and want to spend more time in it. Therefore, the first step is to clarify the relationship between the community museum users and the elements of nature and artifice. When establishing an assessment system for the quality of community museums, it is necessary to analyze them in terms of their harmony of architecture and context, visual expression and artistic design, usability and activities, cultural expression and transmission, ecological sustainability, and management and maintenance.

Harmony of architecture and context

Community museums should respect the original natural and humanistic environment of the city. As a part of urban space, community museums are the connection and transition

between the natural and artificial environment of the city, and more importantly, they should absorb the essence and characteristics of the city culture and promote and spread them in their own space [41]. Community museums should be in harmony with their surroundings and environment, respecting the original characteristics of the surrounding environment. After all, they are part of the community; it is also important to make good use of the surrounding environment to better guide and encourage the public to enter.

In some cultural facilities, especially in museums, visitors' experiences are rarely realized at rest, but in a state of constant movement [39]. People follow paths to experience and perceive space. Thus, space directs the movement of visitors and can stimulate or limit their initiative. Therefore, the connection and transition of public cultural facilities to the street, the openness and privacy restrictions for visitors, and the attractiveness and orientation of passersby affect the impression of the place, so the degree of harmony between cultural facilities and the surrounding natural environment is a factor that must be considered. In considering the harmony of cultural facilities with the urban environment, it is necessary to evaluate three aspects: the coordination of the surrounding natural context, the inducement of urban space, and the accessibility of the community museum.

Visual expression and artistic design

Physical and sensory stimulation is the first step in creating the experience of a community museum. Community museums are usually located within a cluster of community buildings in the city, where the visual aspect of their architecture is important because people are more concerned with environments, they find attractive, and therefore visually attractive environments are more likely to be sound and sustainable [42]. In sensory identification, visuals are also the most direct and primary identification in the user experience process [42]. In terms of human elements, designers also prioritize the visual impact of cultural facilities on the public when designing them; however, vision is never a single existent perceptual experience. Often, vision is accompanied by depth perceptions such as hearing, smell, and touch, integrating architectural elements such as scale, form, light and shadow, materials, sound, temperature, indoor and outdoor environments that influence the spatial experience, and further creating an impressive sense of experience. Different spatial forms generate different visual tensions; these visual tensions come from the morphological elements of their spatial environments that stimulate visual or thinking activities, and the use of different elements of form, color, proportion, and style can create different spatial experiences [36,43]. From the scale of the museum building to the surrounding area and city to the interior space, the relationship between the interior space and people affects the visitor experience. A good scale can attract great attention [44].

The visuals will examine the visitor's experience of the building form and architectural space and the artistic design of the building will also be reflected in the visual dimension, which can together create a positive experience and attraction for the community museum. Assessing the visual expression and artistic design of a community museum can be considered in four aspects: materials and colors, form and style, proportion and scale, and innovative ideas of design.

Usability and activities

Space is all about being used. Based on the specific background and architectural rules, designers give the corresponding functions to the community museum. Space is only meaningful because of human use and activity [42]. The use of a space and its functions directly affect the user's experience of the space. The various functions in a space can generate diverse activities and attract a variety of people, thus triggering multiple event elements and enriching the experience of the space. The mix of uses (whether within a building, a street, or an area) can help to determine how well-used a place is, and what economic and social activities it will support [45]. Appropriate activities can make people participate and leave an impression; however, too many messy activities will distract people's attention and affect people's moods. Therefore, to enrich the community museum, a single function should be avoided, but at the same time should avoid excessive activity

in the limited area. Only by ensuring good usability can we better contribute to the continued vitality of the space. Thus, the diversity, vitality, and convenience of community museums are the focus of the assessment from the perspective of the physical use of their configuration.

Cultural expression and transmission

The cultural content of a community museum is not simply dependent on the exhibits. Culture in the wider sense is also reflected in the architecture and the atmosphere of the space. In people's minds, space is a place and time is an occasion [46]. Just as the occasion of attending an exhibition enlivens an empty hall, the presence of people transforms the otherwise space of a community museum into the warm embrace of a public place. Thus, places derive their meaning and value from people, without whom they would be mere spatial elements defined by their physical characteristics. The emotional impact of a community museum on its users and residents is intangible and cannot be ignored. The public can recognize familiar or interesting things from the many sensory information and make judgments and responses to the information. People are often touched by the messages of the interior spaces of buildings, such as mysterious, sad, lively, cheerful, and so on; it is assumed that the atmosphere conveyed by the architectural space echoes the function and theme of the space. In this case, it can generate a strong sense of identity and belonging, making a strong impression on the users of the space. Even years later, users still remember the memorable experience of the space. Therefore, the connection of the local community with the inheritance of local culture becomes essential. The most satisfying visiting experience for visitors resonates with their experience and provides new information in ways that confirm and enrich their view of the world. Because visitors need to see how community museums are relevant and valuable to their own lives [47]. So, in the field of social and cultural characteristics, community museums need to focus on the inclusiveness and popularity of the content, the significance of culture, and the stimulation of social activities.

Ecological sustainability

Sustainability is increasingly a primary concern of society due to awareness of climate change, shifts in the global economy, and a growing understanding that there are limits to growth. The long-term enjoyment of cultural facilities by the general public should also be taken into account. The notion of sustainability is a holistic worldview that aims to meet the human population's needs while maintaining the natural environment in an un-degraded [48]. For community museums, the use of renewable, pollution-free materials and the adoption of low-energy operation mechanisms are key considerations for their ecological and environmental protection.

Management and maintenance

In addition to design elements such as natural and artificial, the longevity of any building cannot be achieved without reasonable management operation and maintenance. The normal use and safe maintenance of buildings, the environmental and sanitary conditions, as well as the management and operation efficiency, will directly affect the efficiency of public use of community museums. The management and service of community museums should have two characteristics: first, public benefit, which ensures universal public participation; and second, quality and efficient service, which ensures maximum benefit. One cannot be achieved without the other. Activities should be used as a carrier to stimulate the enthusiasm of the public to participate, and cultural activities should be used to drive up the utilization rate of buildings. At the same time, the management of community museums should provide a guarantee for the good operation of public cultural facilities. The facilities that are not fully functional or damaged should be repaired, and the safety hazards should be eliminated promptly to meet the needs of the masses to participate in the activities to the maximum extent possible. Further, a building's use will become historic with time, but the building's strengths should not be reduced, and may even become more attractive as a result of the experience of time.

4. Research Methods

The research methodology is the process to help the researcher to explore and solve the research questions. The theoretical research must be combined with practice to have a more in-depth understanding of the visiting experience of community museums in the city. The experimental research mainly used an evaluation factor system of urban community museums to analyze specific cases to find key indicators that relate to the visitor's experience. Thus, a case study in the field is quite necessary to demonstrate the application of the fuzzy comprehensive evaluation method. Due to the particularity of each individual, this study needs to collect a large amount of data by summarizing the general behavior rules of visitors.

In the case study, data collection will be in the form of a questionnaire. The questionnaire is a quick and efficient means of obtaining large amounts of data from a huge sample of people. The setting of the corresponding questions can reflect the attitudes, preferences, opinions, and intentions of different groups of visitors. Questionnaires can gather information directly from respondents through a series of questions about visitors' feelings and experiences [49]. Typically, a questionnaire includes closed and open questions. Closed questions structure the answer by only allowing responses that fit into pre-decided categories. In comparison, open questions are often used for complex questions that cannot be answered in a few simple categories but require more detail and discussion. In this research, all questionnaires ensure that visitors can complete them in less than 3 min to avoid the negativity presented in the electronic questionnaire due to too many questions. To avoid missing details and limiting the scope for respondents to provide answers that reflect their true feelings about a subject, most closed-ended questions have an open option that allows people to fill in their feelings. Visitors of all backgrounds and ages will be randomly selected for the study in the public spaces of the case, and these recruited respondents are voluntary.

Finally, a total of 100 data were collected for this study. After that, the data will be systematically analyzed by a fuzzy comprehensive evaluation method to come up with a comprehensive evaluation of public cultural facilities by visitors and directions for improvement.

4.1. The Fuzzy Comprehensive Evaluation Method

The fuzzy comprehensive evaluation method is based on fuzzy mathematics (fuzzy set), which was mentioned by the American mathematician Lotfi A. Zadeh in 1965 [50]; its basic principle is to measure the value consistently and without contradiction from the evaluation scale given by the evaluation subject according to the specific situation, to obtain the evaluation results acceptable to most people, and provide the necessary information for correct decision-making; this comprehensive evaluation method integrates the evaluation of objects subject to multiple factors and transforms a qualitative assessment into a quantitative one [51]. Users' experience in community museums reflects the diversity of each individual's feelings and it is difficult to measure quantitatively. Therefore, this study uses the fuzzy comprehensive evaluation method to analyze the design factors of museum spaces to reveal their relationship with the visiting experience. Taking the evaluation process as a systematic project, it is scientific, reasonable, and feasible to choose the comprehensive evaluation method in fuzzy mathematics to quantitatively evaluate the quality of public cultural facilities according to the fuzzy characteristics of evaluation factors.

A fuzzy mathematics comprehensive evaluation model is a comprehensive evaluation of something under the influence of many factors.

Let's assume two finite discourse domains: $U = \{U_1, U_2, \dots, U_m\}$; $V = \{V_1, V_2, \dots, V_n\}$, where U represents the discourse domain (factor set) composed of m factors and V is the discourse domain (evaluation set) composed of n evaluation levels.

People are not positive or negative about n kinds of evaluation. Therefore, the comprehensive evaluation can be regarded as a fuzzy subset $B = \{b_1, b_2, \dots, b_n\}$ of V , and the comprehensive evaluation B depends on the weight distribution of various factors,

which can be regarded as the fuzzy vector $A = \{a_1, a_2, \dots, a_m\}$ of U (the value of the sum is required to be equal to 1). The fuzzy relation R is regarded as a “fuzzy converter”, which is input, A is output and B is shown in Figure 1.

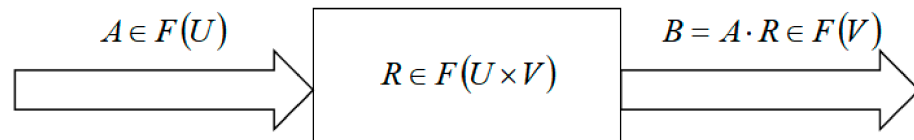


Figure 1. Fuzzy converter.

4.2. Construction of Evaluation Model of Community Museums

According to the analysis in Section 3.2, Table 1 shows the assessment system for the quality of community museums and subsets covered under each section.

Table 1. Evaluation factor system of urban public cultural facilities.

| Index Bed | |
|---|--|
| Harmony of architecture and context U_1 | Coordination of the surrounding natural context u_{11} |
| | Accessibility u_{12} |
| | Inducement of urban space u_{13} |
| Visual expression and artistic design U_2 | Materials and colors u_{21} |
| | Form and style u_{22} |
| | Proportion and scale u_{23} |
| | Innovative ideas of design u_{24} |
| Usability and activities U_3 | Diversity u_{31} |
| | Vitality u_{32} |
| | Convenience u_{33} |
| Cultural expression and transmission U_4 | Inclusiveness and popularity u_{41} |
| | Significance of culture u_{42} |
| | Stimulation to social activities u_{43} |
| Ecological sustainability U_5 | Renewable and pollution-free materials u_{51} |
| | Low-energy consumption operation u_{52} |
| Management and maintenance U_6 | Normal use and safe maintenance u_{61} |
| | Sustainability of strengths u_{62} |

It is necessary to note that harmony of architecture and context U_1 , visual expression and artistic design U_2 , usability and activities U_3 , cultural expression and transmission U_4 , ecological sustainability U_5 , and management and maintenance U_6 , these six main factors are a comprehensive evaluation of the quality of a community museum. For different community museums, due to their differences in nature and environment, the emphasis should be different in the specific evaluation process and should be selected according to the actual situation in the specific application. Certain buildings, as contributors to the attraction of visitors in urban communities, may be extremely outstanding in one respect, allowing other aspects of evaluation to be neglected. For example, a strong visual presence, enough to make a building become a landmark; or a low carbon building that is able to keep warm in winter and cool in summer without the use of energy machinery; these may be things that make the buildings more attractive due to the fact that they are different from other buildings. Therefore, this study will focus on the impact of each factor within each

subset of the six factors above that affect the quality of cultural facilities without comparing and calculating the weights of the relationships between the six main factors.

4.3. The Calculation for the Quality of Community Museums

The fuzzy comprehensive evaluation method is a method to evaluate things collectively in multi-level and multi-factor situations [51]. Because of the complexity, fuzziness, and difficulty in quantifying and defining the quality of community museums, the fuzzy comprehensive evaluation method can be easily calculated, which will make the evaluation results tend to be true and reasonable. According to the comprehensive evaluation index system of community museums quality constructed in Table 1, the fuzzy comprehensive evaluation process can be divided into the following six steps:

(1) Establish the factor set of the evaluation object

According to the comprehensive evaluation index system of community museums quality shown in Table 1, the factor set U is established as follows:

$$U_1 = \{u_{11}, \dots, u_{13}\}; \dots; U_6 = \{u_{61}, u_{62}\} \quad (1)$$

(2) Establish a weight set

Because the position and function of each level and each evaluated factor in the evaluation target are different, and the influence degree of different factors on the evaluation results is different, the weight set A is established, namely:

$$A_1 = \{a_{11}, \dots, a_{13}\}; \dots; a_6 = \{a_{61}, a_{62}\} \quad (2)$$

(3) Establish a judgment set

The evaluation set B can be expressed as:

$$B = \{\text{perfect, very good, good, satisfactory, unsatisfactory}\} \quad (3)$$

(4) Determine the membership degree of the evaluated factor

The membership degree of each factor to the evaluation grade reflects a certain correlation between U, V , that is, the membership degree of each factor to the evaluation grade, thus establishing the membership degree matrix R_1, \dots, R_6 and transforming it into dimension one.

$$R_1 = \text{Matrix } U_1 \times V_1; \dots; R_6 = \text{Matrix } U_6 \times V_6 \quad (4)$$

(5) Fuzzy comprehensive evaluation calculation

After determining the weight set and membership matrix, fuzzy transformation can be used for a comprehensive evaluation and the corresponding evaluation set $B_i (i = 1, 2, \dots, 6)$ is obtained as follows:

$$\left. \begin{array}{l} B_1 = A_1 * R_1 \\ B_2 = A_2 * R_2 \\ \vdots \\ B_6 = A_6 * R_6 \end{array} \right\} \quad (5)$$

In the formula: B_i is the evaluation set of evaluation indexes of cultural facilities in urban public space; “ $*$ ” is the operator.

(6) Determine the evaluation results

Using the maximum membership method, that is, taking the evaluation set factor corresponding to the maximum evaluation index $\max_1 B_{1j} (j = 1, \dots, 3); \dots; \max_6 B_{6j} (j = 1, 2)$ as the evaluation result of the public space quality in each section, the quality of the community museums can be obtained.

5. Empirical Analysis

The New Art Exchange (NAE) is located in the main concentration area of the African and Asian immigrants and their descendants, and next to the Hyson Green Community Centre of Nottingham city [52]; it was designed by Hawkins\Brown Architects and built in 2003 with the primary aim of showcasing the cultural richness and diversity of the region; it is the largest gallery in the UK dedicated to culturally diverse contemporary visual art and the first dedicated African, African Caribbean, and South Asian contemporary visual art community museum in the UK [52,53]. Before proceeding with the design, the design team did a lot of research with young people in the local areas; they found that many people in the area recognized the need for a cultural building, such as a museum or gallery, that could reflect the multicultural nature of the area [54]. The site is already surrounded by two Victorian buildings—a community center and a Baptist church, both of which are solid and serious in their architectural style. Using simple geometric volumes and individualized windows, New Art Exchange presents a modern community museum in dark gray, with a form that creates a distinct visual clash with the surrounding traditional red brick buildings [53] (Figure 2). The New Art Exchange's sustainability concept is integrated throughout the design. Together with the community center next to NAE, it undertakes to display the diverse local culture and provide communication activities for residents. Holidays and weekends are often crowded with people who bring their children to activities. To further explore the impact of NAE on community vitality, a previously established system of evaluation factors for urban public cultural facilities will be used to verify the performance of NAE in terms of function, visual design, and sustainability.



Figure 2. New Art Exchange and its surrounding buildings (The church is on the left and the community center is on the right). (Photo by Zheng X., 2019).

This section takes the NAE in Nottingham as an example, and its comprehensive evaluation index system is shown in Table 1. ten experts in the fields of architectural design, museum, and urban design were invited to give the weight of each factor on the quality of cultural facilities. Furthermore, a questionnaire was used to ask visitors for their subjective assessment of each item. After that, the scientific quality assessment results are provided for NAE through the fuzzy comprehensive evaluation method, and suggestions are provided for its future development.

5.1. Establishing a Fuzzy Matrix of Factor Evaluation

The researcher translated evaluation items from Table 1 into questions in a questionnaire and collected data from 100 visitors. Interviewees will select their corresponding rating level (perfect, very good, good, satisfactory, or unsatisfactory) for each question. The options for each question for these 100 interviewees were then summed and converted into the corresponding scores.

According to the summary of visitors' subjective assessment of the visiting experience of the NAE, the number of people who belong to the evaluation layer of each evaluation factor layer in the questionnaire survey is the membership of the evaluation index. Then, based on the data in the table, the fuzzy matrix R_1 to R_6 of a single factor, evaluation is established. See Tables 2–7 for details.

Table 2. Membership in the evaluation index 1.

| R_1 | | Perfect | Very Good | Good | Satisfactory | Unsatisfactory |
|---|--|---------|-----------|------|--------------|----------------|
| Harmony of architecture and context U_1 | Coordination of the surrounding natural context u_{11} | 7 | 23 | 64 | 6 | 0 |
| | Accessibility u_{12} | 36 | 42 | 12 | 10 | 0 |
| | Inducement of urban space u_{13} | 18 | 28 | 31 | 21 | 2 |

Table 3. Membership in the evaluation index 2.

| R_2 | | Perfect | Very Good | Good | Satisfactory | Unsatisfactory |
|---|-------------------------------------|---------|-----------|------|--------------|----------------|
| Visual expression and artistic design U_2 | Materials and colors u_{21} | 12 | 14 | 38 | 24 | 12 |
| | Form and style u_{22} | 20 | 28 | 33 | 19 | 0 |
| | Proportion and scale u_{23} | 19 | 25 | 36 | 18 | 2 |
| | Innovative ideas of design u_{24} | 27 | 28 | 35 | 10 | 0 |

Table 4. Membership in the evaluation index 3.

| R_3 | | Perfect | Very Good | Good | Satisfactory | Unsatisfactory |
|--------------------------------|----------------------|---------|-----------|------|--------------|----------------|
| Usability and activities U_3 | Diversity u_{31} | 7 | 23 | 52 | 18 | 0 |
| | Vitality u_{32} | 5 | 10 | 41 | 38 | 6 |
| | Convenience u_{33} | 21 | 27 | 37 | 14 | 1 |

Table 5. Membership in the evaluation index 4.

| R_4 | | Perfect | Very Good | Good | Satisfactory | Unsatisfactory |
|--|---|---------|-----------|------|--------------|----------------|
| Cultural expression and transmission U_4 | Inclusiveness and popularity u_{41} | 36 | 38 | 26 | 0 | 0 |
| | Significance of culture u_{42} | 42 | 35 | 20 | 3 | 0 |
| | Stimulation to social activities u_{43} | 20 | 29 | 36 | 15 | 0 |

Table 6. Membership in the evaluation index 5.

| R_5 | | Perfect | Very Good | Good | Satisfactory | Unsatisfactory |
|---------------------------------|---|---------|-----------|------|--------------|----------------|
| Ecological sustainability U_5 | Renewable and pollution-free materials u_{51} | 3 | 7 | 69 | 15 | 6 |
| | Low-energy consumption operation u_{52} | 0 | 14 | 58 | 20 | 8 |

Table 7. Membership in the evaluation index 6.

| R_6 | | Perfect | Very Good | Good | Satisfactory | Unsatisfactory |
|----------------------------------|--|---------|-----------|------|--------------|----------------|
| Management and maintenance U_6 | Normal use and safe maintenance u_{61} | 39 | 40 | 21 | 0 | 0 |
| | Sustainability of strengths u_{62} | 42 | 39 | 19 | 0 | 0 |

For the establishment of the fuzzy matrix R_1 to R_6 for factor evaluation, the specific process is as follows:

$$R_1 = \begin{bmatrix} 7 & 23 & 64 & 6 & 0 \\ 36 & 42 & 12 & 10 & 0 \\ 18 & 28 & 31 & 21 & 2 \end{bmatrix}$$

$$\vdots$$

$$R_6 = \begin{bmatrix} 39 & 40 & 21 & 0 & 0 \\ 42 & 39 & 19 & 0 & 0 \end{bmatrix}$$

5.2. Make Fuzzy Comprehensive Evaluation

Each of the ten experts gave a weight to each section, and then the data from ten individuals were summed to give the weight of each section by finding the proportion to the total, the result is shown in Tables 8–13.

Table 8. The weight of Section 1.

| R_1 | Weight | |
|---|--|-------|
| Harmony of architecture and context U_1 | Coordination of surrounding natural context u_{11} | 34.7% |
| | Accessibility u_{12} | 33% |
| | Inducement of urban space u_{13} | 32.3% |

Table 9. The weight of Section 2.

| R_2 | Weight | |
|---|-------------------------------------|-------|
| Visual expression and artistic design U_2 | Materials and colors u_{21} | 30.4% |
| | Form and style u_{22} | 32% |
| | Proportion and scale u_{23} | 13.5% |
| | Innovative ideas of design u_{24} | 24.1% |

Table 10. The weight of Section 3.

| R_3 | Weight | |
|--------------------------------|----------------------|-------|
| Usability and activities U_3 | Diversity u_{31} | 39.5% |
| | Vitality u_{32} | 29.7% |
| | Convenience u_{33} | 30.8% |

Table 11. The weight of Section 4.

| R_4 | Weight | |
|--|---|-------|
| Cultural expression and transmission U_4 | Inclusiveness and popularity u_{41} | 36% |
| | Significance of culture u_{42} | 34.8% |
| | Stimulation to social activities u_{43} | 29.2% |

Table 12. The weight of Section 5.

| R_5 | Weight | |
|---------------------------------|---|-------|
| Ecological sustainability U_5 | Renewable and pollution-free materials u_{51} | 42.1% |
| | Low-energy consumption operation u_{52} | 57.9% |

Table 13. The weight of Section 6.

| R_6 | Weight |
|----------------------------------|--|
| Management and maintenance U_6 | Normal use and safe maintenance u_{61} 49.1% |
| | Sustainability of strength u_{62} 50.9% |

5.3. The Evaluation Calculation

According to the formula in step 5 of the fuzzy comprehensive evaluation method in Section 4.3 and combined with the data derived from Sections 5.1 and 5.2, the matrix and weights will be multiplied and will result in a fuzzy comprehensive evaluation result for each section $B_i (i = 1, 2, \dots, 6)$.

Fuzzy comprehensive evaluation results of R_1 :

$$\begin{aligned}
 B_1 &= A_1 * R_1 \\
 &= (34.7\% \ 33\% \ 32.3\%) * \begin{bmatrix} 7 & 23 & 64 & 6 & 0 \\ 36 & 42 & 12 & 10 & 0 \\ 18 & 28 & 31 & 21 & 2 \end{bmatrix} \\
 &= (20.123 \ 30.885 \ 36.181 \ 12.165 \ 0.646)
 \end{aligned}$$

In the same way, fuzzy comprehensive evaluation results of each aspect are:

$$\begin{aligned}
 B_1 &= A_1 * R_1 = (20.123 \ 30.885 \ 36.181 \ 12.165 \ 0.646) \\
 B_2 &= A_2 * R_2 = (19.12 \ 23.339 \ 35.407 \ 18.216 \ 3.918) \\
 B_3 &= A_3 * R_3 = (10.718 \ 20.371 \ 44.113 \ 22.708 \ 2.09) \\
 B_4 &= A_4 * R_4 = (33.416 \ 34.328 \ 26.832 \ 5.424 \ 0) \\
 B_5 &= A_5 * R_5 = (1.263 \ 11.053 \ 62.631 \ 17.895 \ 7.158) \\
 B_6 &= A_6 * R_6 = (40.527 \ 39.491 \ 19.982 \ 0 \ 0)
 \end{aligned}$$

5.4. Evaluation Result Analysis

The result calculated by the fuzzy comprehensive evaluation method will reflect the degree of affiliation. In simple terms, it is the degree to which the evaluation result is affiliated with the judgment set, $B = (\text{perfect, very good, good, satisfactory, unsatisfactory})$. Based on the above calculations, the following conclusions can be drawn based on the principle of affiliation:

Visitors had varying levels of agreement with the six indicators of NAE's evaluation. The study will select the largest affiliation evaluations as the result of the evaluation of the item. "Harmony of architecture and context" is rated as "good (36.181)"; "visual expression and artistic design" is "good (35.407)"; "usability and activities" is "good (44.113)"; "cultural expression and transmission" is "very good (34.328)"; "ecological sustainability" is "good (62.631)"; "management and maintenance" is "perfect (40.527)".

Among them, the evaluation grades of "harmony of architecture and context", "visual expression and artistic design" and "usability and activities" are all "good", indicating that the reasonable location, high accessibility, and rich content in terms of spatial layout and functional use of the museum, and the appearance and stylistic design easily attract people's attention lay the foundation for visitors to have a good visiting experience. As an urban community museum, NAE is reasonably well performed in these respects. Of course, there is some space for this to develop, for example, the building's shape could be made more innovative, or the building could be used to host more community or even city events. The visitors rated "very good" for "cultural expression and transmission", which shows that the visitors recognize the contribution of the museum to the promotion of regional culture and the management and development model of NAE. From the calculations, the evaluation is very close to "perfect (33.416)"; this shows that the museum is successful in its presentation of culture and that NAE is able to take on the role of a public cultural facility for the city; furthermore highly rated was the "management and maintenance" aspect.

As the building has been in use for nine years, the interior of the building is repainted or redecorated for almost every exhibition. Both the interior and the façade bring a sense of cleanliness and tidiness without the vicissitudes of history. The various activity rooms and the library are well managed by the network, can be used by internet reservation and are followed up and maintained by staff members. In the aspect of “ecological sustainability”, visitors rated “good”, which is a modern building that does not stand out in this field, suggesting that it is difficult for visitors to experience the low-carbon or environmental protection design concept during the visit, which could be due to visitors’ limitation of related knowledge and directly reflects that NAE still needs further improvement in the aspect of environment-friendly design and promotion.

Visitors’ recognition of the four indicators of “cultural expression and transmission” is at a high level, which shows that visitors have a high evaluation of the understanding of the exhibition’s content and people activities and behaviors of the NAE and are willing to participate and integrate into them. The NAE provides a place for residents to connect, interact, and learn. Here, connections are made between places and people and between people through cultural exhibitions; perhaps, it can be more oriented toward contemporary issues and family visitation in the local area. Parents might take their children to learn important lessons in the museum, not fully taught in school. The museum is a place to promote communication and interaction with the city and visitors, and residents and visitors.

Community museums serve to enhance the local image and help residents build pride and self-confidence to maintain the stability of the community and promote economic development. Only community museums with a good visiting experience can have a sustained attraction, inviting more people to enter the place and thus promoting various interactive behaviors. Establishing an effective evaluation system for community museums, therefore, provides a guiding basis for designing such architectural spaces in the future, helping designers to cater to users’ preferences more efficiently.

6. Conclusions

Born in the new museum movement, the essence of the community museum is the restraint of urban renewal, the heritage and preservation of the historical lineage and the promotion of the gradual development of the local cultural personality in the process of urban change. Community museums emphasize the culture and environment behind the city and allow visitors to experience the value and charm of urban culture in an immersive way. The evaluation system for the quality of community museums established in this study bridges the gap in the relationship between museum design and visitor experience. Through the application of the fuzzy comprehensive evaluation method, the subjective visitor experience is reflected in the quality of each space of the museum with objective data, thus providing a more scientific, realistic, and specific development plan for the museum; it is important to note that each city has its own regional characteristics and habits, so the quality evaluation results of community museums in different regions are bound to be different, and museums need to optimize and improve according to their local conditions and the needs of visitors. Based on the limitation of time and manpower, this study only focuses on the quality evaluation of community museums. The evaluation system is based on the principle of human-centeredness and explores the impact of museum space design on their experience from the perspective of users, so it can be subsequently extended to serve more urban public spaces.

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