Research on Open Learning Based on Art Education in Smart Museum

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Abstract. With the digital development of museums and the continuous extension of their educational functions, the Smart Museums are facing new opportunities and challenges. At the same time, there is a growing demand for open learning in society. Based on the construction and application of E-GPP-C intelligent learning model supported by artificial intelligence, this study discusses the issues related to open learning in the digital age. The Qulia model method is used to analyze museum collections at three levels, score and sum the evaluation index factors of sensory quality characteristics, and find out the most sensitive collection. This paper proposes learner portraits based on subject knowledge map and big data technology analysis, constructs open learning methods, and provides quantitative representation of subject objectives for open learning practice of art education in Smart Museum.

Keywords: Smart Museum · E-GPPE-C model · Qualia model · Art Education · Open Learning

1 Introduction

On May 24, 2021, the National Development and Reform Commission, together with The Publicity Department of the Central Committee of the CPC and the State Administration of Cultural Heritage, issued *Guidelines on Promoting Museum Reform and Development*. The Smart Museum is based on the digital museum development, is based on the museum core business intelligence. From the technical point of view, the Smart Museum relies on the Internet of Things, cloud computing, big data and mobile Internet, etc. With the rapid iteration of digital technology, virtual reality and augmented reality and other technologies provide the museum with a variety of platform and means, make it possible for open learning is possible.

2 Art Education in Smart Museum

Under the background of cultural power, museums and galleries, as cultural communicators, assume the function of art education for citizens. At present, many museums have enriched and expanded their educational functions with blockchain technology. Smart
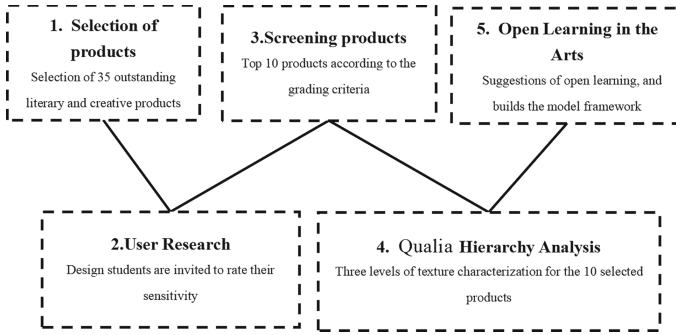
Fig. 1. Research Path of Qualia model Method (Author's Drawing)

Museums have become a new way to meet the cultural needs of the public, improve the level of public knowledge and artistic literacy. The term Qulia was coined by Clarence Ivring Lewi. It is a feeling that cannot be obtained without personal experience, a psychological phenomenon, a state of consciousness, a sensory activity. Chalmers (1996) believes that the Qualia substance is the most basic intuition of human beings, and it is the most direct knowledge like the mind [1]. Figure 1. Shows the research path of this study using Qualia theory.

2.1 Art History is Deeply Interpreted by Qualia Characteristics

Museums and art galleries are the most concentrated places of artistic achievements in a country or region, collecting outstanding works created by artists and skilled craftsmen of all dynasties and generations. [2]" All history is contemporary," says Benedetto Croce, whose digital technology restores museum artifacts from a historical perspective, in 2D graphics and pictures, 3D models, and 3D animation and dynamic digital collections (Fig. 2).

From the Qualia level: internal, external and spiritual level and the relationship between the Smart Museum, it can be divided into art level, Qualia level and representation level, as shown in Fig. 3. Qualia characteristics of museum collections: material characteristics, behavioral characteristics and spiritual characteristics, as shown in Fig. 4.

The evaluation of the qualia feature is based on the user's investigation, which requires the user to sum up the evaluation index factors of a product:

$$S_j = \sum_{i=1}^{n} x_i \qquad (1)$$

in the formula S_j——Sum of evaluation scores for a particular user (assuming 30 users, respectively S1, S2, S3……S30);

n——Number of evaluation indicators (that is, there are several evaluation indicators, and there are 18 evaluation indicators in the table, that is, n = 18);

x_i——The evaluation scores of the i factor (i.e. the average scores of the corresponding indicator masses);
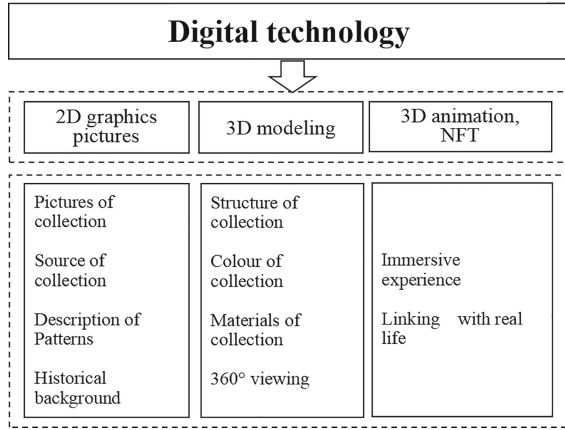
Digital technology

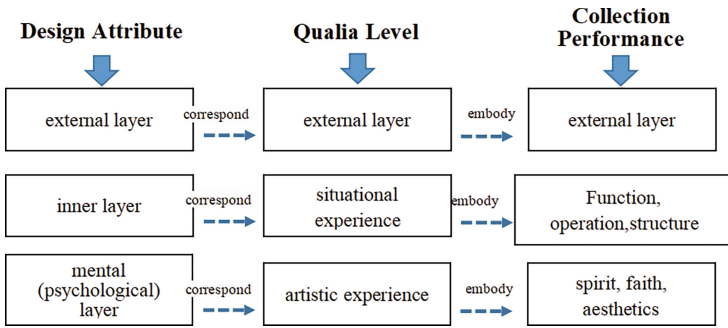| 2D graphics pictures | 3D modeling | 3D animation, NFT |

Pictures of collection	Structure of collection	
Source of collection	Colour of collection	Immersive experience
Description of Patterns	Materials of collection	Linking with real life
Historical background	360° viewing	

Fig. 2. Digital technology restores museum artifacts

Design Attribute → **Qualia Level** → **Collection Performance**

external layer	correspond →	external layer	embody →	external layer
inner layer	correspond →	situational experience	embody →	Function, operation, structure
mental (psychological) layer	correspond →	artistic experience	embody →	spirit, faith, aesthetics

Fig. 3. Qualia Level and Collection Relationship Diagram (Author's Drawing)

Material Characteristic
Styling Appearance   Color Material

Behavioral Characteristic
Usage   Scenario
Mode of operation
Specification

Mental Characteristic
Legend   story
historical background
cultural connotation
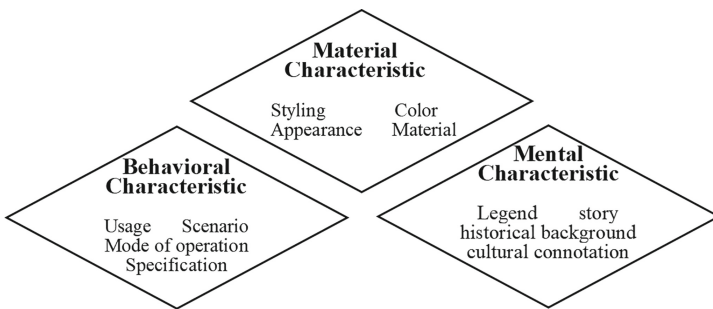
Fig. 4. Analysis Chart of Collection Qualia (Author's Drawing)

Average the total score of the product by all participating users:

$$\overline{X} = 1/m \sum\nolimits_{j=1}^{30} S_j \tag{2}$$

In the formula m——Total number of people surveyed;

J——Number of items (That is the number of people);

This formula first finds the sum S_j of each user's scores for 18 indicators of a product, and then adds the sum S_j of all users for the product to find the average $\overline{X}$. In this way, the data of 35 products can be obtained and their scores are sorted, and then the top ten products are selected, and the scores obtained by these ten products are averaged to obtain $\overline{Y}$, which is used as the standard to judge whether the products have sensory properties. For example, the final average of $\overline{Y} = 65$ for these ten products indicates that a product must achieve at least this score to indicate that it has sensory properties.

Digital 2D graphics and pictures are a kind of artistic interpretation, mainly including original cultural relics picture materials, cultural relics materials and their secondary creative products. The original photographic materials mainly display the overall or partial appearance of the relics, including the detailed information of the collection, the description of patterns, historical background and so on, It has certain aesthetic value and historical research value. The digital 3D model is based on the cultural relics in

Table 1. Product Qualia characteristics rating table

Qualia product characteristics	Evaluation factor	Score range
Charm(A)	Features of product use (A1)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product Features are what I need (A2)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Products with Stories (A3)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product Personification (A4)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
Aesthetic feeling(B)	The product is smooth and aesthetically pleasing (B1)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product styling with impressive features (B2)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Highly integrated product shape (B3)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product shape is very well proportioned (B4)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product design can be accepted by everyone (B5)	1 ● ● ● ● ● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree

(*continued*)

Table 1. (*continued*)

	Simple and elegant product design (C1)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
Originality(C)	Innovative product design (C2)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Products in line with current trends (C3)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	The product combines ancient and modern qualities (C4)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
Delicacy(D)	Product appearance Exquisite workmanship (D1)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product details meet functional requirements (D2)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product details and overall consistency (D3)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
Engineering(E)	Product operation is cultural(E_1)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree
	Product operation is smooth(E_2)	1 ●●●●● 5 Absolutely disagree Disagree Neutrality Agree Absolutely agree

(Author's Drawing)

the collection as the prototype, and is made by relying on modern digital technology and blockchain technology. It emphasizes the restoration of the structure, color and material of the physical collection, breaks the traditional restriction of viewing the partial collection through the glass, and can be rotated 360°to view and learn. The museum's 3D animation or dynamic digital display is a typical example of the museum's largest investment in art history and the comprehensive and multi-angle interpretation of art history. For example, in December 2021, the digital collection series of Bingxi Map in the Imperial Palace was sold in the form of blind box. This is an effective attempt by the National Museum of China and the 4D Era to transform the Palace Museum's collection of Bingxi into a 3D animated digital collection with 3D technology. The promotional video "Winter Olympics in the Forbidden City" officially released by the Beijing East Olympic Organizing Committee, with cultural interpretation of the movement, with cultural relics to confirm civilization.

2.2   Intelligent Learning Model E-GPPE-C and Museum Aesthetic Education

In the era of artificial intelligence, intelligent learning is characterized by learner-centered, goal-oriented, process-oriented and evaluation-oriented. Figure 5 shows the E-GPPE-C intelligent learning model based on six core elements: environment, map, portrait, path, evaluation and community. The model includes base layer, support layer, service layer, key layer and application layer from bottom to top. The core of the model is to support the open learning of museums [3].

As a pioneer of aesthetic education in modern China, Cai Yuanpei put forward the slogan "Aesthetic Education Instead of Religion" in 1917. He believed that aesthetic education has three aspects: family, school and society. After the birth of Marxism, its brand-new concept laid a solid foundation for the theory of museums and art galleries, and it has more guiding significance for the public to develop aesthetic education. The effectiveness of museum aesthetic education is also the behavioral layer of Qualia model.

According to incomplete statistics, since 2021, about 30 domestic have participated in the digital collection wave. Among them are the National Museum of China, the National Palace Museum, Henan Museum, Dunhuang Museum, Shanghai Museum, Gansu Museum and other well-known museums. On November 22, 2021, Dunhuang Academy of Fine Arts jointly launched the first dynamic digital collection of Dunhuang Art Series with the Oriental Art Creation Studio. This digital collection is based on Dunhuang murals "Flying Dance Map", combined with animation, music and other digital processing methods, vividly restored the magnificent scene of court music and dance. The mural tiles from the Wei-Jin period of Gansu Province Museum and Nanjing Museum. It is the only two remaining relics of the Wei-Jin period in China. The museum applies traditional art forms, patterns and colors through digital collections to extend beauty to life, and promotes the popularization of art through digital collections.

The economic behavior of converting the collection into digitally reproduced goods is also a way for museums to carry out aesthetic education, reinforcing the modern
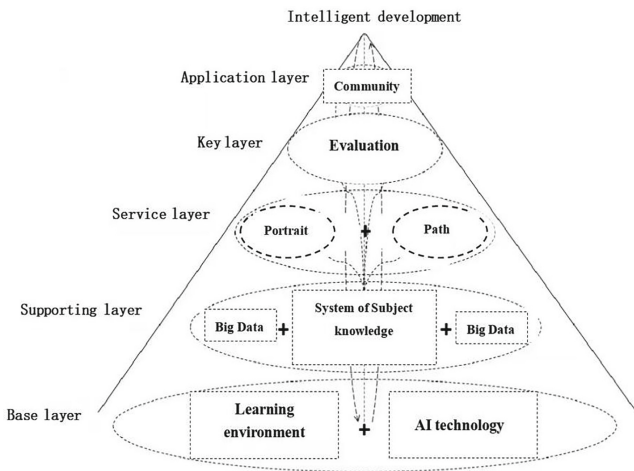
Fig. 5.   Intelligent learning model supported by AI
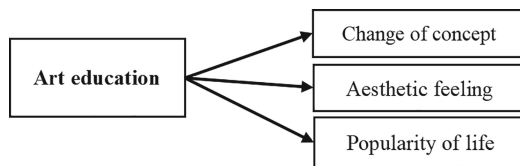
Fig. 6. Art education efficiency of Smart Museum

application of traditional culture and enhancing national pride. Therefore, based on the inheritance of civilization, the Museum of Wisdom follows the three elements of story, inheritance and elemental product development, and combines culture with creativity. (Fig. 6.)

2.3 Multimodal Interpretation of Artistic Style

Qi Heritage Museum is located in Zibo, is a national first-class museum, not only contains the wine culture of the state of Qi 2400 years ago, but also has the silk fabric of the state of Qi "Qi wan", more countless bronze and museum treasure Si Zun", "Qi Dao coin" has an important position in the history of Chinese currency and metal casting history. [4] The Qi culture has created an open, pragmatic, transformative and inclusive culture in the millennium of development, which shows the perseverance and struggle spirit of the Qi people. At present, the digital construction of the museum is limited to the "appointment visit" and "audio tour" of the Wechat official account, as well as the "collection fine products" picture browsing and the video browsing of the "data center" of the official website. It is biased towards the traditional field visit, and the intelligent construction is slightly lagging behind. No Big Data to support.

Shandong Qingzhou Museum was rated as the national first-class museum in 2008. And was the only County-level comprehensive museum selected that year. The new museum opens in May 2023. The 3D digital exhibition attracts many visitors for the museum's "immersion experience".

The Smart Museum integrates the senses of sight, hearing and touch, and interacts with the audience in a multimodal manner, not only interpreting the essence of traditional culture, but also integrates base layer, support layer, service layer, key layer and application layer. The collection of Yangzhou Grand Canal Museum reflects more than 10,000 pieces of ancient books [5], paintings, calligraphy, inscriptions, ceramics, metalware miscellaneous and other cultural relics from Spring and Autumn period to the contemporary canal theme. There is a good learning environment. In the exhibition hall, an immersive experience space, "5G + VR 720° Live Broadcasting," was set up to show the beauty of the canal. (Fig. 7.)

More and more Smart Museums have incorporated gamification into their exhibition designs, moving from physical to virtual online games in addition to traditional games. The aim is to stimulate initiative in interaction and guide people to walk into, understand and fall in love with the traditional culture of the museum through internal driving force. The Palace Museum Press interactive puzzle-solving game book "Maze As One Wishes" breaks through the traditional way of reading, integrates historical and cultural knowledge with the game process in the interaction, cracks the dusty history in the game

Fig. 7. Yangzhou Grand Canal Museum multimedia exhibition hall
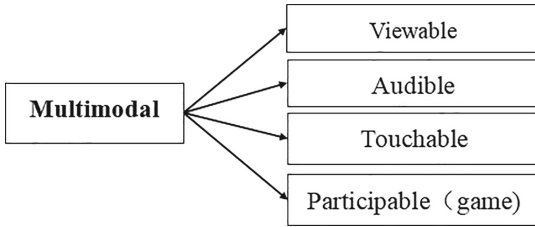

Fig. 8. Multimodal interpretation of artistic style

puzzle solving, and opens the door of interest. The sticky experience of the game itself helps to enhance the in-depth understanding and memory of cultural knowledge. [6] (Fig. 8).

3   Open Learning in the Arts

Open learning goes beyond traditional teaching and is an open mode of learning content, environment, means and process. The museum is a non-profit organization for education, research and appreciation, collecting, preserving and presenting to the public human activities and natural environment witnesses, with a relatively free space for self-directed learning. [7] As a way to break through the limitations of time and space and enrich the collection, the Smart Museum dilutes the boundaries between physical museums, and makes the connection between the museum's collection, exhibits and audience reach the best degree.

3.1   Digital Technology Enhances Interest in Art Learning

Professor James Elkins of the Chicago Institute of Fine Arts believes that "art cannot be taught", and says that about five in a thousand art students end up making a living from their art, and only one in a thousand will become famous outside their home city. The core of open learning lies in "openness", its purpose is diversified learning objectives, open teaching environment and multi-dimensional teaching design, and give full play to students' subjective initiative. Table 2 is a questionnaire for visitors to Hubei Provincial Museum. Fig. 9. Shows the itinerary of visitors to the museum.

A total of 200 questionnaires were sent out, 200 were recovered, and 195 were valid. Among them, 67.69% of the visitors were older freelancers or students, the number

Table 2. Questionnaire outline of Hubei Provincial Museum

| Category	Problem design
Basic information	age, sex, occupation
conventional problem	How to learn the knowledge of museums Frequency of going to museums in Hubei Province Frequency of online browsing The reason for going to the museum in Hubei Province Order of Viewing Exhibits Favorite exhibit (or exhibition hall)
problem of expansion problem	Do you visit actively or passively? What do you think is the biggest gain?
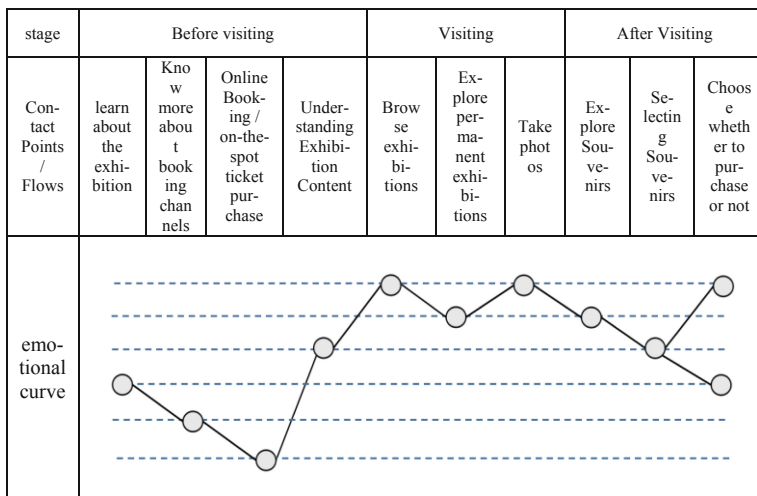
Fig. 9. User journey chart

of men and women was equal, and 32.31% were people with stable jobs, indicating that museum education is much more attractive to freelancers and students than other groups. 93.83% of users have only been to Hubei Provincial Museum once, and the online page views are large, indicating that digital museums have great learning resources and potential. 75.38% of the people chose to go to Hubei Provincial Museum because of cultural influence and art learning. 87.69% of users browse randomly and spend more time browsing the treasures of the museum, indicating that the dissemination of cultural knowledge and art of the museum's landmark collections is far greater than that of other categories of collections. 91.6% of users are active visitors, and their biggest harvest is the edification of art. It also holds that art derivatives (includingNFT) realize the unity of art and function to a certain extent, indicating that the derivatives of digital museums have not only unique creative symbols, but also design beauty and life beauty.

In addition, the user journey chart directly confirms the above conclusions for the feelings before, during and after the visit. Digital technology makes the classification of museum collections more clear and the data path easier to find, and the audience can actively explore and learn according to their own preferences. Compared with passive infusion learning, independent exploration and learning have better learning effects.

3.2 Open Learning Stimulates Creative Thinking and Aesthetics

Undoubtedly, open learning can bring joy to learning and a shift in thinking patterns. Creative thinking first means to break through the inherent ideas and traditions, and the open learning mode will push people to constantly break through the thinking, ideas and behavior patterns. Taking Hubei Provincial Museum as an example (Table 3), the products with strong sensory properties are based on the research of 35 previous products. The table is as follows:

Table 3. Design sources of Qualia products and museum derivatives

Product	Source	Product	Source	Product	Source	Product	Source	Product	Source
01 Storm bottle		02 Playing card		03 Pencil case		04 Mouse pad		05 Tea set	
06 Cutlery set		07 Yellow Duck		08 Hat		09 Mirror		10 Tumbler	
11 Umbrella		12 Floral organ		13 Fruit dish		14 File		15 Sachet	
16 Archaeological blind box		17 Signet		18 Chest clip		19 Cutlery set		20 Tumbler	
21 Sleeper light		22 Book light		23 Notebook		24 Bracelet		25 Teacup	
26 Timepiece		27 Aroma box		28 Tumbler		29 Pendant		30 Facial mask	
31 Incense holder		32 Mirror comb set		33 Note paper		34 Pat light		35 Note paper	

(Source of table: Author's Drawing; Product source: The Internet)

The individuals surveyed in this study are mainly design students, who have certain aesthetic ability and can understand different levels of connotation of scoring products. The 35 products were scored on a total of 18 options based on the five characteristics of charm, beauty, creativity, refinement and engineering in Table 1. A total of 300 questionnaires were distributed online, and 285 valid questionnaires were received. According to the perception evaluation index system established in Chapter 2, individuals from the 285 valid questionnaires of the research and investigation summed up the scores of each index of each product:

$$S_j = \sum_{i=1}^{n} x_i \tag{3}$$

In the formula Sj - The sum of a user's rating scores (here S1, S2……S45);

n - The number of evaluation indicators (that is, there are several evaluation indicators, there are 18 evaluation indicators in the table, that is, n = 18);

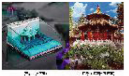xi - the evaluation score of the item i factor (i.e. the average score of the corresponding indicator crowd);

The 35 products are represented by numbers (01, 02……35), and survey individuals are represented by P (P1, P2…… P285), see Appendix 5 for detailed data. The results of the survey are shown in Table 4.

The sum of the scores of each individual for each product S_j is added to find the average:

$$\overline{X} = 1/m \sum_{j=1}^{30} S_j \tag{4}$$

In the formula m - Total number of people surveyed (285 here);

j - the number of items (i.e. the number of people);

Table 4. Summary of product scores by survey individuals

Products/survey individuals		P_1	P_2	P_3	......	P_{283}	P_{284}	P_{285}
01		77	48	53		54	49	59
02		47	50	55		55	54	57
......	......							
34		76	48	65		53	51	57
35		62	51	56		61	57	61

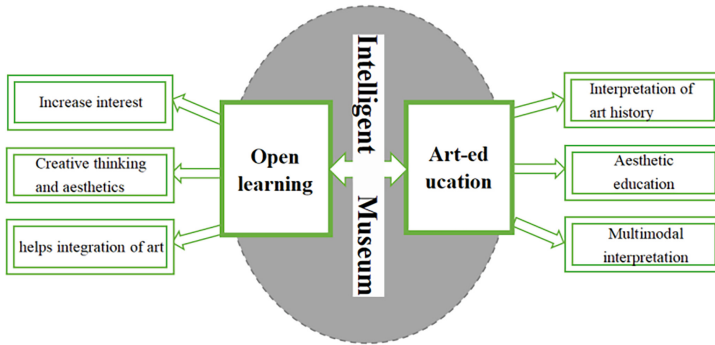**(Source of table: Author's Drawing; Product source: The Internet)**

Fig. 10. The relationship diagram of open art education based on the Smart Museum

The average of evaluation indicators of each product was calculated one by one, and 10 products with high scores were selected according to the final total average score for the classification of sensory quality at three levels.

Jerome Seymour Bruner, an American psychologist and educator, believes that students' mental development, though partly influenced by their environment, is primarily governed by their own knowledge. Open teaching based on the vast amount of museum knowledge helps students to grow their wisdom and cognition.

3.3 "Storeroom Display" Helps the Integration of Art

Openness is mainly manifested in the learning content and the form of organizational activities, which provides learners with the opportunity of free choice and the environment of inquiry in many aspects and all-round aspects. Learners take the initiative in learning by themselves and choose the fields they are interested in to search for relevant information. "Stockroom-style display" originally intended to transform the exhibition hall according to the space of the storeroom. The exhibits were displayed on a large scale and systematically. [8] These include lectures and training on the museum's art culture, Saturday Art Public Lecture, Children's Art Gallery, and amateur art training, both online and offline.

In addition, the digital collection, as the infrastructure of the meta-universe, is a bridge between the future digital world and reality. From a postmodern standpoint, this study suggests that the meta-cosmic framework can be perfected by enhancing the social attributes of digital collections, building digital communities and digital personal museums. [9] The public welfare of the smart museum determines its community nature. The relationship between the Museum and open learning is as follows (Fig. 10).

4 Conclusion

This paper uses the intelligent learning model E-GPPE-C to propose a learner portrait based on subject knowledge graph and big data technology analysis. Uses Qualia model and summation formula principle, based on the art education function of Smart Museum,

divides museum collections into three levels, Use the product Qualia Characteristics rating scale to identify the most distinctive museum collections, it is believed that digital technology restores the museum's art collection in a multi-modal way.

From the perspective of open learning, this paper analyzes the results of questionnaire, user journey map, design source table of sensory quality products and museum derivatives, and demonstrates the intelligent learning method based on six core elements: environment, map, portrait, path, evaluation and community. It is believed that the Smart Museum can stimulate creative thinking and facilitate the integration of knowledge through social learning and open learning, and provide quantitative representation of subject objectives for the open learning practice of art education in the Smart Museum. In the era of rapid development of artificial intelligence, the art discipline plays a role in creative thinking for the whole society, and the ways andl methods of open learning will be more diversified in the future.

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