Exploring the Factors of Cooperation between Artists and Technologists in Creating New Media Art Works: Based on AHP

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Abstract: The deeper the combination of art and technology, the more extensive the cooperation between artists and technologists. In many cases, the creation of New Media Art requires the cooperation of artists and technologists. However, since New Media Art is an emerging art form, the process of cocreating New Media Art between the two is at the exploration stage. Especially in areas with underdeveloped New Media Art and underdeveloped technology, there exist many problems in the cooperation between the two, such as a lack of complete understanding of the factors involved in the cooperation process and a lack of reasonable planning for the cooperation process. Therefore, this study analyzes the factors that affect the collaboration process between the two creating New Media Art. Common factors are collected from the literature and then added or deleted after expert opinions. Then, analytical hierarchy process (AHP) method is applied to get the weight of each factor and understand the influence degree of the factor. The research results show that there are relatively fixed factors influencing the collaboration process between artists and technologists in creating New Media Art, and various factors have different degrees of influence on cooperation. Therefore, in the process of cooperation between the two parties, more emphasis should be placed on the factors of cooperation, which makes the cooperation more scientific.

Keywords: artists; scientific and technological workers; New Media Art; cooperation process; AHP
(such as cooperation conditions, project management, feedback and evaluation, cooperation results, etc.), but directly focused on the part of “cooperative interaction behavior.” On the other hand, they paid less attention to the establishment of cooperation conditions as well as feedback and evaluation. The demonstration of the construction cooperation conditions is directly related to actual operations, so most of them are mentioned in specific actual cases, while theoretical research pays little attention to this part. Regarding the feedback and evaluation, it is currently unclear why it is less considered in the research. In order to further study the cooperation theory of the two, for the reference of artists and scientific and technological workers, this research carried out a series of work. The first is to construct a cooperative factor system for artists and technologists to create New Media Art works by searching literature and consulting experts, and second, using questionnaire surveys and AHP analysis method (a simple and flexible multicriteria decision-making method for quantitative analysis of qualitative problems), to integrate the opinions of relevant people in the field on the weight of cooperation factors. Finally, some valuable information is obtained from the final weight results.

This study considers the entire process of cooperation between the two parties from “construction of cooperation conditions” to “cooperation feedback and evaluation,” thus makes up for the shortcomings of previous studies that often only focus on the process of cooperation and interaction. A relatively complete system of cooperation factors is established, and the degree of importance of cooperation factors is examined. Some of the thoughts derived from the research will have a positive guiding role for artists and scientific and technological workers to create New Media Art works, avoiding them from paying attention only to certain aspects involved in the cooperation, and helping them to establish a more comprehensive understanding.

This research is divided into several parts: The first part is literature review, sorting out the literature achievements and actual progress in two important aspects of “New Media Art” and “interdisciplinary cooperation.” Then in the “summary,” the deficiencies of previous studies are pointed out and the work done in this study is clarified. The second part is methodology, which takes the three steps of the AHP method as the main body, and introduces the research process, research materials, and research results of this research in detail. The third part is the result and discussion. According to the weight data obtained in the second part, the analysis and discussion are carried out from the two perspectives of “comparative analysis of the weight of each factor” and “comparative analysis based on basic information.” The fourth part is the conclusion, summarizing the research methods, research conclusions, research significance, and limitations of this research.

2. Literature Review

2.1. New Media Art

The earliest works of art that can be called “New Media Art” can be traced back to the 1860s. The main topics related to New Media Art in the early days were technical aesthetics, art technology, science and art, information aesthetics, and cybernetics in art [1]. At that time, because of the limited technology, the research objects were relatively few. The main research objects were computer graphics, computer science, film, video, sculpture, and participatory art forms in computer art. In addition to personal research, “Leonardo” magazine, as a front of technical and artistic issues, records early research and discussion since 1968 [2].

After 2000, due to the gradual maturity of digital technology in art, many publications began to appear in the field of New Media Art. Discussions on New Media Art mainly included: First, discussions on the types of its branches. For example, discuss virtual art and mixed reality, computer art and software art, telematics art, network art, game art, malfunction art, activism, hacktivism and tactical media, biological art and genetically modified art, stage art, and New Media Art. The second is the discussion of its research methods. Mainly to incorporate New Media Art into the dimension of art history, including examining the connection between New Media Art and avant-garde art in the 20th century; other research methods include media archeology, image science, etc. The third is the
discussion on its sorting, restoration, and preservation. Since 2000, the practice of New Media Art has become more active, and the issues of display, restoration, and preservation of New Media Art have been paid more and more attention. The protection of digital heritage has become a problem faced by many museums and cultural institutions. Currently, museums, universities, and online archives can provide protection measures [3].

New Media Art is an art form supported by digital media and information communication technology [2]. Meanwhile, digital art is regarded as the main content of New Media Art, so they always replace each other in some literature [1]. New Media Art in a broad sense includes digital art (algorithm art, processor art, digital film, and digital animation), mobile art, network art, software art, glitch art, interactive art, virtual reality art, biological art, and more types.

The emergence and development of New Media Art has academic significance and application value. For example, in the field of academic research, New Media Art illustrates the politics and culture of the digital age, and is a tool for understanding the digital society, so it has great inspiration for research fields such as “digital sociology” and “art sociology in the digital age” [2]. In the field of application, New Media Art has created new economic growth points in the cultural field. It is used in commercial spaces (commercial exhibitions, corporate exhibition halls, advertising and marketing, and amusement parks), museums or exhibition halls, public spaces [3], education [4], stage performance, New Media Art exhibitions, etc. Numerous New Media Art teams and companies have emerged to seize opportunities. Briefly, New Media Art is a window to understand the digital society and helps boost the economy.

Existing research mainly focuses on the historical origin, aesthetic connotation, practical application, and case description of New Media Art. However, the research on the creative process of New Media Art is still fewer, less research on the factors involved in the creation of New Media Art by artists and technologists, and a complete system of cooperative factors has not yet been established.

2.2. Interdisciplinary Cooperation

2.2.1. Extensive Interdisciplinary Cooperation

Interdisciplinary cooperation is getting more research and promotion. Interdisciplinary cooperation is the integration of multidisciplinary personnel and knowledge to solve complex or comprehensive problems. Or when the ability to innovate is insufficient, the collision of multidisciplinary thinking can generate new inspiration and produce innovative results. The current interdisciplinary cooperation has been very extensive and flexible, and cooperation in almost any discipline can be carried out, such as the cooperation of architects, landscape practitioners, ecologists, etc., to design natural inclusive and inclusive cities [5]. In addition, the AI field combines artificial psychology, linguistics, computer science, mathematics, and other disciplines for research [6].

There are some research results in interdisciplinary cooperation. For example, Cheng focused on the knowledge interaction in interdisciplinary cooperation and proposed an overall conceptual model of interdisciplinary team knowledge interaction in research universities. The antecedent variables of knowledge interaction include team member attributes, team task characteristics, team interactive environment, and team interaction resources; knowledge interaction process variables mainly include knowledge divergence and knowledge aggregation; and knowledge interaction result variable is mainly knowledge interaction performance [7]. Xing et al. studied the influencing factors of knowledge integration in interdisciplinary teams, including personal emotional needs, interpersonal relationship needs, knowledge integration environment, knowledge integration methods, knowledge dispersion, and knowledge differences, and revealed the law of knowledge integration in interdisciplinary teams [8]. Interdisciplinary cooperation is not only a method adopted by people in the industry but it is also recommended as an important training project in higher education [9].
2.2.2. Interdisciplinary Cooperation in the Fields of Art and Technology

Art and technology have a close relationship in the history [10], but at present, the interdisciplinary cooperation between art and technology has become deeper.

From a certain period to the present, there have been a few institutions, publications, and activities promoting interdisciplinary cooperation between art and technology. For example, EAT (Art and Technology Experiment) builds bridges between artists and scientific and technological workers [10]. The tasks they do include: providing scientific and technological information; guiding artists to use computers and industrial equipment; publish the newspaper “EAT News” and four publications to report on art and scientific events; establish branches around the world to connect artists and art organizations with local technological and industrial resources; find and protect industrial sponsors of the project, such as large industrial enterprises, schools, foundations, laboratories, governments, scientific research institutions, etc., which provide opportunities for many resident projects; and organize exhibitions, document compilation, and archive collection (reports on their own activities, exhibition catalogues, information, periodicals, speeches, art reviews, etc.). Besides, Symbiosis A laboratory was founded in 2000 and belongs to the School of Anatomy and Human Biology, University of Western Australia. It welcomes all artists, writers, and researchers interested in exploring the potential of science and technology to join as resident scholars. It also encourages undergraduates, postgraduates, artists, and scholars from various disciplines to work together in interdisciplinary research teams to explore innovative directions for new technologies [11]. The services it provides to partners include training courses, resident research projects, and workshops. Art and technology information exchange platform includes specialized academic journals, academic conferences, and online communication platforms. In addition, there are various exhibitions or competitions related to art and technology, such as the Austrian Linz Art Festival.

Research on interdisciplinary cooperation between art and technology is also emerging. For example, Balint and Pangaro proposed that by introducing boundary objects at the intersections of disciplines, communication barriers between art and technology personnel can be eliminated. Boundary objects can take root in ideas and build up language diversity among various disciplines. These artifacts were created to support the convergence of participants towards a common shared language. [11]. This article proposes a new classification of boundary objects from design and cybernetic methods. Tanaka mentioned that collaborative research between artists/designers and scientists/engineers has always been ambitious. However, how to achieve success is still a persistent question. Furthermore, an innovative method that can combine art, design, science, and engineering is proposed as a framework for effective collaboration. In addition, they considered using the idea of “universe” to connect experts from different disciplines. This concept was developed by engineers from the European Organization for Nuclear Research and designers from the Geneva Advanced School of Art and Design as mediators [12].

2.2.3. Interdisciplinary Cooperation in the Field of Art and Technology to Create New Media Art Works

New Media Art has a new form, which usually requires a higher level of technology to achieve it, so the creation of New Media Art mostly requires the cooperation of personnel. In this kind of cooperation, scientific and technical personnel use technical means and artists direct artistic performance. However, the open source platform can currently be used for creation, i.e., the artist only needs to understand the basic knowledge and framework of the program to make specific creations, which greatly reduces the threshold of creation technology. (For example, when you create on processing software, you can use the program modules preset by the programmer to reorganize and optimize to generate new works [4].) However, the use of the platform preset by the technicians limits the creativity to a certain extent—this method cannot produce specific solutions based on the specific requirements of creation. Furthermore, although there are many outstanding New Media Art creators who have mastered both technical and artistic abilities, in the actual creative process, they also
need to consult or seek help from scientific and technical personnel in some aspects. Completely independent creation is relatively rare. Therefore, when funds, manpower, and time are relatively sufficient, the cooperation between scientific and technical personnel and art workers is essential.

Moreover, the cooperation between art and technical personnel is by no means such a relationship, i.e., the artist is only responsible for conceiving and directing, and the scientific and technical personnel are only responsible for observing and installing. The cooperation between artists and scientific and technological workers mainly has the following levels: the first level is technical cooperation, which is the artist’s contribution to the skills of artistic expression, and the scientific and technological workers contribute technical support. The second level is ideological cooperation. In creation, artists tend to quote aesthetics, art history, cultural studies, etc., and are good at using metaphors and chaotic expressions. However, scientific and technological workers have different knowledge contributions according to different subject backgrounds. For example, biologists propose genetics and artificial life, computer experts propose digital imaging and construct models, physicists propose quantum mechanics and relativity, etc. They are good at revealing the mysteries of the natural universe [10]. The third level is the joint contribution to society. The significance of the cooperation between artists and scientific workers is not limited to a specific collaboration, but represents the communication between two cultures. Art is seen as having humanistic thinking, and technology is seen as having natural rationality. If artists, scientific, and technological workers share common concerns in the fields of society, politics, humanities, and ecology and jointly create works on topics such as digital society, the polarization of rich and poor, human destiny, and ecological protection, they will attract attention from both fields.

There are some case studies describing the process and details of interdisciplinary collaboration in the field of art and technology to create New Media Art works. For instance, Brumley et al. introduced the Bird Song Diamond (BSD) digital installation art, which was completed by a cooperative team formed by ecology and bird biologists, signal processing experts, computer science experts, and artists. The cooperation form of this project is a series of cooperation, from the installation of the early version of Bird Song Diamond (BSD) to the installation of the latest version, i.e., the scale, software complexity, and sculptural elements are all steadily increasing. Each iteration of the design gradually adds more components to the overall bill of materials [13]. Another case is Schofield et al. describing a virtual reality exhibition developed by an interdisciplinary team composed of artists, engineers, and others. After the project was completed, the cooperation team used questionnaires to investigate the visitor experience during the exhibition, and they also conducted self-evaluation, which both reflected the feedback evaluation process of the project [14].

There are also some theoretical studies that summarize some of the factors involved in collaborative creation of digital art. For example, Steinheider and Legrady pointed out that the factors that affect cooperation and coordination are systematic project management, time management, and stability of team creation. Aspects related to knowledge sharing include common understanding of goals and problems, terminology sharing, experience in interdisciplinary work, and motivation to work in an interdisciplinary team [15]. Adério and Nelson believe that the creative process of digital art is mainly divided into several stages, i.e., conceptual design, narrative design, experience design, aesthetic contemplation, aesthetic concerns, technological innovation, artifact design, realization of artifacts, and art exhibition planning [16]. Pershina et al. introduced the “iterative design process,” which includes the following activities: conception, document creation and improvement of related materials, prototyping, user testing, analysis, and summary. These activities are usually repeated many times; in each process, the works can be more perfect, and the combination of multidisciplinary knowledge tends to be more mature [17]. Sleigh and Craske pointed out that the funder’s evaluation of the project is insufficient. Art works that combine art and science almost completely lack strict censorship. For example, the Welcome Foundation did not evaluate the artistic quality of its sponsored results in its report. The Calouste Gulbenkian Foundation censored the entire plan, but it has not been published and cannot be traced back [18].
2.3. Summary

The shortcomings of previous studies are that, first, the focus is more on the part of “direct cooperation and communication.” For example, researchers have proposed an overall conceptual model of knowledge interaction, the influencing factors of knowledge integration, and the introduction of boundary objects to eliminate communication barriers and integrate digital art. The creative process is summarized from conceptual design to the planning of art exhibition. The studies above did not fully demonstrate the factors of the “whole process” of cooperation, but directly focused on the part of “cooperative behavior.” Second, there is less attention to “construction of cooperation conditions” and “cooperation feedback and evaluation.” The demonstration of “construction of cooperation conditions” is directly related to actual operations, so most of them are reflected in specific actual cases, and theoretical research pays little attention to this part. “Cooperation feedback and evaluation” can effectively enable artists and technologists to have a clear understanding of the current cooperation effects and accumulate valuable experience for future cooperation, but there is no abundant research in this area. All in all, previous studies lacked a summary of the “entire process” of cooperation between the two parties and lacked understanding of the importance degree for various factors of cooperation.

There are three main tasks to be done in this research. First, consider the early and late factors that impact the process of cooperation between artists and technologists and form the five “main factors” including construction of cooperation conditions, cooperative project management, cooperative interaction process, performance of cooperation results, and cooperation feedback and evaluation. In addition, the subfactor system of 25 subfactors was constructed. After that, we further consulted experts to add, delete, as well as calibrate the factors. This factor system is expected to be a relatively complete system at this stage. Second, after structuring the factor system, this research will conduct a quantitative study on the factors in this system to examine people’s relatively precise views on the importance of different factors. Therefore, questionnaire surveys are to be used to obtain the original data of the respondents’ opinions, and then, the AHP method will be applied to calculate and analyze the weight of the factors, and finally, we can know the importance level of each factor. The third is to classify respondents from different perspectives, examining the characteristics of different types of people’s opinions on various factors and drawing some conclusions. In general, through the combination of qualitative research and quantitative research, this study will be expected to produce content that artists and scientists can refer to when they collaborate to create New Media Art.

3. Methodology and Implementation

Based on the research ideas of the AHP method, this paper uses the way of questionnaire survey to investigate the cooperation factors of artists and technologists in creating New Media Art works and obtain the weight of each factor.

The AHP method is a simple and flexible multicriteria decision-making method for quantitative analysis of qualitative problems proposed by the American operations researcher and Professor T.L. Saaty of the University of Pittsburgh in the early 1970s. So far, there have been many applications of AHP methods, such as establishing an evaluation system for something [19], such as helping decision-making through priority division [20], and other applications contains generating alternative solutions, solving resource allocation, establishing performance measurement, resolving conflicts, etc. There are also other applications about how to use the AHP method to analyze the factors that affect a project or a process, such as analyzing the success factors of project management [21] and analyzing the driving factors in the system [22]. Therefore, the AHP method is determined to be suitable for analysis of collaboration factors between artists and technologists in creating New Media Art works in this research. The concrete steps of this study using the AHP method and questionnaire survey are as follows.
3.1. Step 1: Build a Hierarchy System

This study found out the main factors and subfactors that influence the cooperation between artists and technologists to create New Media Art works by consulting the literature and established a preliminary table of cooperation factors. Then, 10 industry experts were invited to add or delete factors in the system. Because no more than seven items are placed in a menu on our computer, there are no more than seven elements in each layer of the hierarchical structure, and the Table 1 of cooperation factors is finally formed.

Table 1. The Factor System of Cooperation Between Artists and Technologists in Creating New Media Art Works.

| Main Factor                          | Subfactor                               |
|--------------------------------------|-----------------------------------------|
| Construction of cooperation conditions | Financial support                       |
|                                      | Cooperation platform                    |
|                                      | Technological conditions                 |
|                                      | Information exchange platform            |
|                                      | Art exhibition platform                  |
| Cooperative project management       | Project scope management                 |
|                                      | Project time management                  |
|                                      | Project cost management                  |
|                                      | Project quality management               |
|                                      | Project risk management                  |
|                                      | Project personnel management             |
| Cooperative interaction process       | Cooperative interactive environment      |
|                                      | Cooperative interactive resources        |
|                                      | Knowledge interaction process            |
|                                      | Iterative design process                 |
| Performance of cooperation results    | Coplanning the display                  |
|                                      | Contribution to technology               |
|                                      | Contribution to art                      |
|                                      | Specific work output                     |
|                                      | Derived results of cooperation           |
|                                      | Digital collection                       |
| Cooperation feedback and evaluation  | Self-summary and evaluation              |
|                                      | Audience feedback and evaluation         |
|                                      | Sponsor evaluation                       |
|                                      | Industry or academic evaluation          |

3.1.1. Main Factors

“Construction of cooperation conditions” refers to the establishment of basic conditions for funds, technology, and platforms before cooperation. “Cooperative project management” is defined to be the use of specialized management knowledge and methods during the cooperation period to monitor and control the overall cooperation tasks and cooperating personnel. “Cooperative interaction process” is mainly about the factors involved in the cooperation process, such as a cooperative and friendly environment, available resources, communication of knowledge, iterative design process, etc. “Performance of cooperation results” refers to the value and results produced after cooperation and the follow-up work that needs to be carried out. “Cooperation feedback and evaluation” implies the feedback and evaluation for the cooperation process and output results from the cooperation members, audiences, sponsors, academics, or industry experts after the cooperation.
3.1.2. Subfactors of Construction of Cooperation Conditions

“Financial support” is regarded as research grants obtained from various funding agencies, including charitable foundations, university funds, and corporate sponsorships. “Cooperation platforms” are mainly classified as research institutions funded by foundations, research institutions established by universities, research institutions under the company, etc., providing venues, training, workshops, materials, etc. for artists and technologists to cooperate and communicate, such as the Center for Advanced Visual Studies at MIT and Experiments in Art and Technology (EAT) [23]. “Technological conditions” is the technological support necessary for the creation of New Media Art. New Media Art projects are different from ordinary projects, and the latter may not specifically emphasize technological conditions. “Information exchange platform” consists of specialized academic journals (such as “Leonardo”), academic conferences, online communication platforms, etc. The role is to timely transmit industry and academic information, publish the latest results, and promote the formation of cooperative teams. “Art exhibition platform” refers to specialized exhibitions, competitions, corporate activities, etc., because general art works require a specific display platform after they are produced.

3.1.3. Subfactors of Cooperative Project Management

“Project scope management” is the definition and standardization of the scope of cooperation projects. After the scope is determined, it will help to reduce the waste of time and cost and will also gather the energy of cooperation. “Project time management” is confirmed to be an important plan to ensure that the project is carried out in an orderly manner and completed on time, including clarifying specific activities, ordering activities, estimating the time of the project, and arranging reasonable schedules. “Project cost management” is to ensure that the project is completed according to the scheduled cost and does not exceed the budgeted cost. Specifically, it contains resource allocation, cost control, and others. “Project quality management” is a general term in project management. In the context of cooperation between artists and technologists, it refers to the quality control of project works to avoid inferior works that do not match the funding. “Project risk management” means dealing with uncertain factors that the project may encounter, such as risk identification, risk quantification, formulation of countermeasures and risk control. “Project personnel management” refers to the management and supervision of cooperating personnel from the perspective of managers, including selecting personnel, coordinating relationships, planning organizational structure, team building, etc.

3.1.4. Subfactors of Cooperative Interaction Process

“Cooperative interactive environment” means that teamwork needs to build an efficient interactive environment, create an open atmosphere for expressing opinions, and clarify the common goals of the team. “Cooperative interactive resources” include team relationship resources and organizational memory. “Team relationship resources” refer to the ability of team members to use social networks to obtain internal and external resources of the team [24]. Organizational memory is defined to be historical information that has an impact on current decisions, which is conserved in organizational culture, behavioral routes, organizational structure, operating specifications, and products [25]. “Knowledge interaction process” is about the four stages composed of the generation of initial ideas, knowledge fission, knowledge fusion, and knowledge interaction scheme verification. Its main content is to jointly understand the goals of cooperation, share knowledge [20], use communication tools [18], resolve conflicts, and compromise between disciplines. It is the most concerned part in the “traditional research” about the cooperation between artists and technologists. “Iterative design process” includes the following activities: conception, document creation of related materials, prototype design, user testing, analysis, and summary. These activities are usually repeated multiple times, and in each step of the process, the work will become more complete. This process can be described as a
spiral, and the number of rounds depends on the complexity of the work. The iterative design process can promote experimental attempts and deepen mutual understanding among team members [18].

3.1.5. Subfactors of Performance of Cooperation Results

“Coplanning the display” implies that the results of the cooperation between artists and technologists need to be displayed (including exhibitions, screenings, etc.), and the cooperation of both parties is still needed in determining the display method, adopting display technology, and providing aesthetic support. “Contribution to technology” refers to the enlightenment and contribution to the field of science and technology because of the cooperation between the two parties. Likewise, “Contribution to art” implies the enlightenment and contribution to the field of art. These two contributions belong to the intangible results of the cooperation and have important industry and social values. “Specific work output” is defined as the main output of the cooperation between the two parties, such as artistic works, image works, installation works, electronic works, etc. “Derived results of cooperation” is classified into patents, academic papers, books, activity records, etc., which are also the added value of cooperation that cannot be ignored. Compared with the above, these two results are tangible results of the cooperation and have realistic value as well as immediate return. “Digital collection” tends to be a central topic in the research field, which argues that after the cooperation, the output works and production process materials need to be converted into digital files and stored in the digital archives, aiming for sustainable preservation [26].

3.1.6. Subfactors of Cooperation Feedback and Evaluation

“Self-summary and evaluation” is “the first-party evaluation,” which refer to the cooperating members’ self-summary and judgment on the cooperation process and results. The methods include writing project summary reports, holding summative meetings, publishing project research papers, etc., which can accumulate experience for future cooperation. “The second-party evaluation” is “audience feedback and evaluation,” implying the audience’s experience and suggestions on the collaborative works in the display [14]. The creator and the audience of an art work are a direct interaction relationship, in which the work is produced by the creator and then presented to the audience [27]. The audience’s feelings and evaluation help to improve the quality of the art work. “Sponsor evaluation” is “the third-party evaluation,” which means the professional estimation from the sponsor to examine the utilization rate of funds or platforms. Through the supervision of the cooperation between the two parties, sponsor evaluation is conducive to controlling the quality of the work [19]. “Industry or academic evaluation” belongs to “the fourth-party evaluation.” It is evaluation conducted by industry experts or academic experts, consisting of art critics, engineers, management experts, etc., which makes the random cooperation between the two parties having universal reference significance and greater social value.

3.2. Step 2: Questionnaire Design and Survey

Questionnaire design and distribution: the questionnaire is mainly divided into two parts. The first part is the basic information of the respondents in the questionnaire, and the second part is the comparison of the importance degree of each two factors, which, in detail, is based on the AHP method and requiring the respondents compared the importance degree of each two factors depend on 1–9 scale. The meaning and description of the AHP evaluation scale are shown in the following Table 2 [28]. For all types of respondents, both the method of sending questionnaires by mail and of submitting questionnaires through online software were used to make it more convenient for the respondents to fill in the questionnaire.
Table 2. AHP Assessment Scale and Explanation.

| Evaluation Scale | Definition                        | Explanation                                                                 |
|------------------|-----------------------------------|-----------------------------------------------------------------------------|
| 1                | Equal importance                  | The two being compared are equally important                                |
| 3                | Weak importance                   | Experience and judgment are slightly inclined to one side                   |
| 5                | Essential importance              | Experience and judgment are strongly inclined towards one side              |
| 7                | Very strong importance            | The actual situation shows a very strong preference for one side            |
| 9                | Absolute importance               | There is sufficient evidence to support a certain absolute preference       |
| 2, 4, 6, 8       | Intermediate values               | When a compromise is needed                                                 |

Questionnaire collection: 233 questionnaires were distributed, 108 were recovered, and 62 were valid. For the returned questionnaire, there are two criteria to determine whether the questionnaire is valid: the first is whether the questionnaire data has passed the consistency test, the second is whether the basic information is completed, and finally, the questionnaire that meets both is valid.

Questionnaire distribution target: the distribution target of the questionnaire includes university teachers, students, and industry experts. The main subject backgrounds of the three types of interviewees are technology, art, and management. They all understand New Media Art and some have personally participated in the creation of New Media Art by artists and technologists. The demographic data of the respondents of the final valid questionnaire [29] are as follows (See Table 3).

Table 3. Demographic Profile of Respondents (Total: N = 62).

| Items                     | Options                  | Number of Individuals | %  |
|---------------------------|--------------------------|-----------------------|----|
| Gender                    | Male                     | 25                    | 40.3|
|                           | Female                   | 37                    | 59.7|
| Identity                  | Student                  | 36                    | 58  |
|                           | University teacher       | 10                    | 16.1|
|                           | Designer                 | 6                     | 9.7 |
|                           | Engineer                 | 3                     | 4.9 |
|                           | manager                  | 7                     | 11.3|
| Subject background        | Art                      | 30                    | 48.4|
|                           | Science or technology    | 20                    | 32.2|
|                           | Management               | 12                    | 19.4|
| Have participated in or   | Have                     | 13                    | 21  |
| have not participated in  | have not                | 49                    | 79  |
| cooperation               |                          |                       |     |

Note: “Have participated in or have not participated in cooperation” refers to whether you have participated in the creation of New Media Art by artists and technologists.

According to the results of the questionnaire survey, a pairwise comparison matrix is established. If there are n elements, then $n \times (n - 1)/2$ pairwise comparisons are required. The values for pairwise comparison are $1/9$, $1/8$ ... $1/2$, $1$, $2$ ... $8$, $9$, (the meaning of the scale is shown in the table above). After establishing the comparison matrix, the eigenvalue solution method was used to find the eigenvector value, and then, the weight was calculated. The row vector average value standardization method was used for calculation, which had higher accuracy considering most of the matrices were
inconsistent matrices. The formula of the row vector average standardization method is as follows (See the Equation (1)):

\[
W'_i = \frac{1}{n} \sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad i, j = 1, 2, \ldots, n
\]  

(1)

3.3. Step 3: Judgment of Level Consistency

The values in the matrix of the pairwise comparison is given by the respondents based on subjective judgments. However, due to the large number of judgment levels and factors, it may be arduous for the respondents to keep the consistency of the judgment before and after the comparison. Hence, the consistency check of the value is required. If the degree of consistency of the matrix does not meet the requirements, it indicates that the respondents’ judgment is inconsistent and needs to be analyzed again. To judge the consistency of the matrix, the C.I. value needs to be calculated. The formula is as follows (See the Equation (2)):

\[
C.I. = \frac{\lambda - n}{n - 1}
\]  

(2)

According to the formula, it is necessary to get the \( \lambda \) value before calculating C.I. Thus, the weight obtained above should be used to calculate the consistency vector (represented by the \( V \) symbol) to get the \( \lambda \) value. The formula is as follows (See the Equation (3)):

\[
V_i = \frac{\sum_{j=1}^{n} w_j a_{ij}}{w_i} \quad i, j = 1, 2, \ldots, n
\]  

(3)

After the consistency vector is obtained, the arithmetic mean of the \( \nu \) value can be made use of to obtain the \( \lambda \) value. The formula is as follows (See the Equation (4)):

\[
\lambda = \frac{\sum_{i=1}^{n} V_i}{n} \quad i, j = 1, 2, \ldots, n
\]  

(4)

Finally, the value of \( \lambda \) is brought into the formula to get the C.I. value. C.I. = 0 means that the respondent’s judgment on the importance degree of each two factors is “completely” consistent. Saaty suggests that if RI < 0.1, it can be considered as “better” consistency.

The up-and-down matrix generated from the evaluation scale 1–9 generates different C.I. values under different levels of numbers and becomes a random index (Random Index; R.I.). The ratio of the C.I. value to the R.I. value is called the consistency ratio (C.R.), which is (See the Equation (5)):

\[
C.R. = \frac{\text{C.I.}}{\text{R.I.}}
\]  

(5)

Therefore, when the C.R. value is less than 0.1, the consistency of the matrix is very high. The stochastic index value [30] is as follows (Table 4):

| N | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
|---|----|----|----|----|----|----|----|----|----|
|   | R.I. | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

In this study, the Yaahp software [31] was used to perform the above calculation steps to determine the consistency of the questionnaire data. If the consistency requirements are met, the final weight data will be output; if the consistency requirements are not met, use the adjustment function in Yaahp software to automatically adjusts the consistency of the questionnaire data (of course, this is under the premise of ensuring that the opinions of the respondents are retained to the greatest extent), and then,
the final weight data are outputted. The weight data and analysis results will be displayed in the next section.

4. Result and Discussion

4.1. Weights of Main Factors

The Table 5 shows the weights of the five main factors. The weight of construction of cooperation conditions is the largest, which is 0.3198, and the weight of cooperation feedback and evaluation is the smallest, which is 0.1253. The establishment of cooperation conditions is the basis for all project activities. Without the support of funds, technology, and various platforms, it is arduous to achieve the expected goals of cooperation. As the development of New Media Art and interdisciplinary cooperation is widely valued, the cooperation between artists and technologists will be supported by increasingly mature conditions. Cooperation feedback and evaluation is crucial for turning the collaboration between artists and technologists into a sustainable circular system [32]. However, at present, the two parties’ cooperation in creating New Media Art is still in the preliminary stage of exploration, the “main focus” is on factors directly related to the cooperation process. Sustainability of development will be a future issue.

| Main Factor                          | Weights  | Sequence |
|--------------------------------------|----------|----------|
| Construction of cooperation conditions | 0.3198   | 1        |
| Cooperative project management       | 0.2363   | 2        |
| Cooperative interaction process      | 0.1580   | 3        |
| Performance of cooperation results   | 0.1568   | 4        |
| Cooperation feedback and evaluation | 0.1253   | 5        |

4.2. Weights of Subfactors of Construction of Cooperation Conditions

The Table 6 presents the weight of the subfactors of construction of cooperation conditions. The weight of financial support is 0.1275 which is the largest and has an extremely obvious weight advantage over other factors, while the weight of the information exchange platform is 0.0327 which is the smallest. As mentioned above, construction of cooperation conditions is the most weighted among all the main factors, and under construction of cooperation conditions, financial support is the most weighted, indicating that financial support is the most weighted in the entire factor system. The amount of funds can affect platform conditions, technological conditions, quality of creators, creative enthusiasm, etc. to a certain extent, and is a crucial factor. The importance of funding seems to be obvious. Artists and technologists with project experience will to a large extent agree that starting a project after finding a suitable sponsor is a way to reduce risk. However, there are two situations that indicate the dilemma of obtaining funds for New Media Art projects. First, the high-tech nature of New Media Art determines its high cost. Compared with art forms such as painting, New Media Art requires greater financial support. Second, New Media Art is relatively emerging, so some conservative and relatively underdeveloped areas or institutions will provide relatively little financial support for New Media Art projects. For example, the Massachusetts Institute of Technology can attract major international sponsors companies to provide funding for projects in their media laboratories, but it is difficult for lower status universities to attract external sponsorship for research and development in novel fields. It may be difficult for interdisciplinary research projects to obtain funding from funding agencies because these programs may exceed the traditional expertise of funding agencies [32]. This contradiction makes artists and scientific and technological workers who carry out New Media Art cooperative creation projects need more efforts to obtain financial support.
Table 6. Weights of Subfactors of Construction of Cooperation Conditions.

| Subfactor                    | Weights | Sequence |
|------------------------------|---------|----------|
| Financial support            | 0.1275  | 1        |
| Cooperation platform         | 0.0743  | 2        |
| Technological conditions     | 0.0591  | 3        |
| Information exchange platform| 0.0327  | 5        |
| Art exhibition platform      | 0.0389  | 4        |

Communication platforms are mainly various online communication platforms and exchange meetings, which are used to facilitate communication among industry insiders, deliver the latest news, and spread advanced technology. Community atmosphere is an important feature of digital art practice, and through community-dimensional feedback and peer review, it can assist in the creative process of developing artworks [23]. Online and offline communication platforms are important ways to form a community atmosphere. It is currently given the least weight by the respondents, mainly because New Media Art is still a relatively small circle (especially in China), and industry insiders can directly exchange and pass on experience to a certain extent, so the awareness of constructing the large-scale platform and the community has not yet been popularized. However, when New Media Art becomes a broad form of art in the future, it is possible to popularize specific online and offline communication platforms such as societies, guilds, and committees just like in the fine art field.

4.3. Weights of Subfactors of Cooperative Project Management

Among the subfactors of cooperative project management, project scope management has the largest weight, which is 0.0635, and project personnel management has the smallest weight (0.0228) (See the Table 7). Project scope management is vitally important to the project. The size of the project scope will affect the time and cost required for the project, i.e., planning an enormous project scope may consume additional time and cost, whereas a narrow project scope probably makes it tough to cope with the subsequent expansion of the project in the actual production process. When artists and scientific and technological workers collaborate to create New Media Art works, it usually takes many adjustments to determine the final project scope. For example, when artists are conceiving new media works, they often conceive many forms of expression and content in advance, but when they are put into technical realization, they find that many of their ideas are unrealistic and difficult to achieve with current technology, so they will modify the original plan and leaving some achievable ideas, which make the scope of the project smaller. However, sometimes, artists will be inspired by technical performance, and then generate more inspiration and add many new forms of expression, which will make the scope of the project larger. So, project scope management is very significant, and the situation is complicated.

Table 7. Weights of Subfactors of Cooperative Project Management.

| Subfactor                      | Weights | Sequence |
|--------------------------------|---------|----------|
| Project scope management       | 0.0635  | 1        |
| Project time management        | 0.0476  | 2        |
| Project cost management        | 0.0383  | 4        |
| Project quality management     | 0.0406  | 3        |
| Project risk management        | 0.0271  | 5        |
| Project personnel management   | 0.0228  | 6        |

Project personnel management is regarded as the least important in the survey results, but in term of practical production, the coordination and organization of personnel cannot be neglected [33]. It is the guarantee for the efficient and high participation in cooperative projects to carry out reasonable task
arrangement according to the cooperation personnel’s academic background, personality characteristics, identity status, and other factors.

4.4. Weights of Subfactors of Cooperative Interaction Process

The Table 8 lists the weights of the subfactors of the cooperative interaction process. The cooperative interaction resources have the largest weight (0.0454), followed by the cooperative interaction environment (0.0434). These two are the factors that maintain the continuous motivation of the cooperation. The cooperative interaction resources are the social and knowledge resources available to both parties. They can inject lasting external help into the cooperation and form a dynamic expansion form. Cooperative interactive environment is to establish a cooperative atmosphere to ensure open communication, innovative thinking, and cohesive strength, all of which can make the cooperating personnel have a benign mentality and creative vitality in it.

Table 8. Weights of Subfactors of Cooperative Interaction Process.

| Subfactor                   | Weights | Sequence |
|-----------------------------|---------|----------|
| Cooperative interactive environment | 0.0454  | 1        |
| Cooperative interactive resources | 0.0434  | 2        |
| Knowledge interaction process | 0.0340  | 3        |
| Iterative design process    | 0.0353  | 4        |

4.5. Weights of Subfactors of Performance of Cooperation Results

Among the subfactors in the performance of the cooperation results in the Table 9 below, the weight that contributes to technology is the largest (0.0293), meanwhile, that of digital collection is the smallest (0.0197). Even though the process of producing New Media Art by artists and technologists is largely in the field of art, in the survey conclusions, people believe that contribution of cooperation to “science and technology” is extremely vital. The level of science and technology greatly affects the progress of the development of New Media Art in various regions. Areas with advanced technology have more diverse expressions of New Media Art and have more incentives for innovation; areas with low technological level, however, New Media Art is still in its infancy stage, the combination of technology and art is not deep enough, and it is still in the stage of mainly learning and mastering technological means. Therefore, people’s emphasis on technology has led to people’s choices when facing both art and technology.

Table 9. Weights of Subfactors of Performance of Cooperation Results.

| Subfactor                   | Weights | Sequence |
|-----------------------------|---------|----------|
| Coplanning the display      | 0.0260  | 3        |
| Contribution to technology  | 0.0293  | 1        |
| Contribution to art         | 0.0246  | 2        |
| Specific work output        | 0.0269  | 3        |
| Derived results of cooperation | 0.0231  | 4        |
| Digital collection          | 0.0197  | 5        |

In the survey results, the weight of digital collection is the smallest, which shows that people pay less attention to the collection and storage of New Media Art at this stage. The reason for this phenomenon may be that the questionnaire for this study was issued in China where the collection and storage of New Media Art is still an area to be developed. However, internationally, there are more researches on the collection and storage of New Media Art [26]. In countries and regions where, New Media Art is in its infancy stage of development, New Media Art is undergoing drastic changes. People are thinking more about how to produce richer and more creative forms of expression and how to quickly use New Media Art to create social topics and attract public attention. However,
the consideration of large-scale digital collection and storage of New Media Art is temporarily put aside. However, in the future, this mechanism will be more perfect.

4.6. Weights of Subfactors of Cooperation Feedback and Evaluation

The Table 10 shows the weights of the cooperation feedback and evaluation. Among them, the industry or academic evaluation has the highest weight (0.0614), and the self-summary and evaluation has the lowest weight (0.0194). Industry or academic evaluation is the most professional evaluation. Industry or academic evaluation is regarded as the most professional evaluation, including but not limited to management experts' evaluation of cooperation mechanisms, art critics' criticism for works of art from an artistic perspective, and engineers' evaluation for the technological content and innovative achievements of works. They are of guiding and summarizing significance for the cooperation between the two parties, reference significance for the entire industry and academic research.

| Subfactor                          | Weights | Sequence |
|------------------------------------|---------|----------|
| Self-summary and evaluation        | 0.0207  | 4        |
| Audience feedback and evaluation   | 0.0348  | 2        |
| Sponsor evaluation                 | 0.0259  | 3        |
| Industry or academic evaluation    | 0.0439  | 1        |

The weight of self-summary and evaluation is relatively small, which indicates that in collaborative creation, neither artists nor technologists can achieve an objective evaluation of their own output. In particular, the artists and technologists tend to judge the part of the other party’s accomplishment from one’s own standpoint, which may lead to prejudice and contradiction. As a result, expert evaluation, audience evaluation, and sponsor evaluation are deemed more objective and comprehensive method.

All in all, if the artist creates independently, he can grasp the direction and aesthetic meaning of his own creation, so he has a clearer understanding of the value of the artwork he created. However, the works created by artists and scientific and technological workers need to be evaluated by a third party, because the cooperation between the two parties involves an issue of “equality” [16], and the two parties are not a simple relationship dominated by artists or scientists. The evaluation of the work should consider the feelings of both parties and maintain their creative enthusiasm and sense of responsibility. Therefore, it is inappropriate for both parties to make arbitrary subjective evaluations. The third-party evaluation mechanism is conducive to both parties to recognize the advantages and disadvantages of the work and to learn experience and lessons, which is beneficial to the virtuous circle of the cooperation process.

4.7. Comparative Analysis Based on Basic Information

4.7.1. Analysis Based on “Different Subject Backgrounds”

This part analyzes the opinions of respondents with three backgrounds of art, technology, and management on the weight of the five “main factors” in cooperation. As shown in Figures 1–3, some of their opinions are consistent, that is, they all believe that construction of cooperation conditions and cooperative project management have the most weight, and based on this consensus, they can be more coordinated in future cooperation. After the fixed conditions (less random) such as cooperation conditions and project management are set up, the entire cooperation process will proceed smoothly.
mechanism is conducive to both parties to recognize the advantages and disadvantages of the work and to learn experience and lessons, which is beneficial to the virtuous circle of the cooperation process.

Table 10. Weights of Subfactors of Cooperation Feedback and Evaluation.

| Subfactor                        | Weights | Sequence |
|----------------------------------|---------|----------|
| Self-summary and evaluation      | 0.3027  | 4        |
| Audience feedback and evaluation | 0.3486  | 2        |
| Sponsor evaluation               | 0.2590  | 3        |
| Industry or academic evaluation  | 0.4390  | 1        |

4.7. Comparative Analysis Based on Basic Information

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Figure 1. The weight given to the “five main factors” by respondents with an “art background”.

Figure 2. The weight given to the “five main factors” by respondents with a “science or technology background”.

![Figure 1](image1.png)

![Figure 2](image2.png)
Figure 1. The weight given to the “five main factors” by respondents with an “art background”.

However, in terms of the other three subfactors, people with artistic backgrounds believe that the process of cooperation and interaction is more weighted, while people with scientific and technological backgrounds and management backgrounds believe that the performance of cooperation results is more weighted, indicating that to a certain extent, people of distinct backgrounds attach different emphasis on these flexible conditions (more random). People tend to prioritize the things they think are more vital according to their own thinking habits. This may, at the beginning of the project, lead to conflicts and misunderstandings about what is more vital to the entire team. It is necessary to strengthen dialogue during cooperation [34] and organize the opinions of all parties to form a fixed “team plan” instead of an “individual plan.”

4.7.2. Analysis Based on “Have Participated in or Have Not Participated in Cooperation “

This part is to analyze the opinions of those who “have participated in” and “have not participated in” the creation of New Media Art between the two parties on the weight of “all factors” of the cooperation. Figures 4 and 5 below presents that people who have participated in collaborative creation have a clear bias towards the importance of several factors of cooperation. They consider the three main factors of “cooperative condition establishment”, “cooperative project management,” and “cooperative interaction process” and their subfactors to be more significant. Those who have not participated in collaborative creation present no obvious preference for the importance of the various factors in cooperation, tending to think that there is only relatively small disparity in the importance degree of each factor. This reflects that the people who have participated in the cooperation may have a strong feeling about the factors of the cooperation due to their actual experience, while those who have not participated in the cooperation are judged based on intuition or past knowledge, as a result, they have a relatively vague understanding of the factors and give them relatively balanced attention.
This conclusion is meaningful for the team, because if some members of the team have not participated in such projects before, they will be in a state of cognitive blur in the early stage. Additionally, if the experienced members are not aware of this problem and fail to guide them in time, they are likely to waste more time on adaption to the cooperation process, which makes the progress of the work between members uncoordinated and hinder the rapid advance of cooperation.
5. Conclusions

In this study, we first constructed a cooperative factor system for artists and scientific and technological workers to create new media works by consulting literature, then asked experts to add and delete factors in the system through questionnaires, and finally, integrated literature research and expert opinions to form the final cooperative factors system table. Next, the questionnaire survey method is used to collect the interviewees' pairwise comparative opinions on the cooperation factors of artists and scientific and technological workers in creating new media works, and then the statistical results of the questionnaire are analyzed based on the AHP method. Our main goal is to establish a relatively complete system that includes as much as possible the factors involved in the creation of New Media Art by artists and scientific and technological workers. This system table (see Table 1) can become a reference table, and artists and scientific and technological workers can collaborate according to this overall process. In order to establish such a system table, we conducted research on “New Media Art,” “interdisciplinary cooperation,” “project management,” and “cases of artists and scientific and technological workers cooperating in creating New Media Art.” After synthesizing...
these data, we established a “preliminary system table,” and then, we consulted experts to modify
the factors in the system table to form the “final system table.”

Although our main goal is to establish such a system table, as an in-depth study, we still need to
investigate every factor involved in this system table. First, we examined the importance level of these
factors. According to the questionnaire survey and AHP method, people’s opinions on the importance
level of each factor are obtained, and the importance level is expressed by “weight.” The conclusion is
that although these factors are all factors involved in the cooperation, they have various differences
to the overall cooperation. The instinct importance reflects some problems, which need to be considered
by artists and scientific workers. After examining the importance level of each factor, we further
divided our survey respondents into different groups investigating how different groups of people
have different opinions on the importance of cooperation factors. On the one hand, it is divided into art
background, science and technology background, and management background according to different
disciplinary backgrounds. On the other hand, according to whether they have participated in the
project of New Media Art by artists and technology workers, the respondents are divided into those
who have participated in cooperation and have not participated in cooperation. The conclusion is that
different characteristics of members will lead to different understandings of the cooperation process,
which will affect coordination, so effective communication and team planning are necessary.

The research outputs of this article are mainly to build a comparatively integrated cooperative
factor system for artists and technologists to create New Media Art works, present the respondents’
options on the weight of each factor, explain the reasons why the respondents have these opinions,
and critically analyzed the reasonableness and unreasonableness of these opinions.

The limitation of this research is that, on the one hand, due to the confined analysis dimensions,
the construction of the cooperative factor system for the creation of New Media Art works by artists
and technologists may still be defective. Nevertheless, academic research on cooperation factors system
is expected to become more complete on account of the extensive cooperation in the future. On the
other hand, because “New Media Art creation” and “interdisciplinary cooperation between artists and
scientists” are still relatively new topics, people do not possess thorough knowledge of them, leading
to some limitations in the final survey results. With the development of the two fields in the future,
people are likely to have more experience with the importance of the factors involved and draw more mature conclusions.

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