Article

Sound Design of Guqin Culture: Interactive Art Promotes the Sustainable Development of Traditional Culture

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Abstract: Culture, as an intangible piece of heritage, is one of the priorities of sustainable conservation. With the rapid modernization of science and technology, traditional culture that is expressed in the form of sound is facing prominent problems related to inheritance and development. Thinking about how to integrate traditional culture into the daily life of the public is an important way of solving sustainability problems related to traditional culture. This study took Guqin culture as its research object, explored the possibility of using sound as an interactive medium, and considered how to present traditional culture to the public in public space to broaden the inheritance and development mode of Guqin culture. Therefore, this study proposes a public Sound Interaction Design Model oriented to sound and presents a public sound-interactive installation with different levels based on the model. The feasibility of the model is verified through an interactive design evaluation method, and the role of the model in sustainable cultural development is discussed.

Keywords: cultural sustainability; public interactive installation; sound design; Guqin culture; design model

1. Introduction

Sustainability includes social, economic, ecological, and cultural dimensions [1] and requires every effort to preserve irreplaceable resources [2]. Cultural sustainability is an integral component of sustainability [3]. The protection of intangible cultural heritage plays an important role in cultural sustainability [4]. The protection of intangible cultural works has become even more important, as UNESCO adopted a convention for the safeguarding of intangible cultural heritage in 2003, which China joined in August 2004 [5]. By December 2020, a total of 42 Chinese items had been added to UNESCO's Intangible Cultural Heritage List. The protection of intangible cultural heritage to achieve sustainable cultural development is one of the priorities of cultural protection and of development in various countries, and its protection is being strengthened year by year.

At present, traditional Chinese culture, with a long history and rich in connotations, is facing a prominent problem of inheritance and development. Most traditional culture is stored in museums in the form of ancient paintings and calligraphy, ancient artifacts, and other physical forms. The public's contact with these artefacts of traditional culture is limited to visual observation in the form of texts, pictures, and objects. It is even more difficult for the public to interact with musical instruments, whose main cultural connotation is in the form of sound, such as the Chinese Guqin, Erhu, and Pipa. These profound and excellent traditional cultures can neither be well understood and recognized by the public, nor can they find a suitable way of being integrated into the daily life of the public. Such heritage is gradually losing its existence, and more attention needs to be provided to preserve cultural heritage [6]. It is far from enough to promote and protect traditional culture through museums and classroom education alone [7]. In addition, at

a time when innovative technologies are gradually being applied to all aspects of people's lives, cultural expressions that mainly take place in the form of memorials and museums can no longer fully meet the spiritual needs of the public, especially those of young people.

The cultural changes that are driven by modernization should not lead to the loss of society's connection with traditional culture. The cultural connotations and historical origin of traditional culture can inspire and nourish contemporary design theory and support the development of creativity in design practice. On the contrary, designs with connotations deriving from traditional cultural can also improve the cultural satisfaction of consumers [8], play an important role in preserving cultural heritage, and spread culture and enhance cultural confidence to support the sustainable development of culture in contemporary contexts [9]. At present, innovative designs that are based on traditional culture are constantly emerging, such as public art design and digital cultural design, which all promote the sustainable development of traditional culture. Although previous studies have conducted many successful design practices, few research studies have discussed the sustainable development of traditional culture that comprise sound as their main form of cultural connotation in modern society.

Taking the Guqin culture as an example, this study explored the construction of a sustainable development model with sound as the interactive subject for traditional culture and considered how to present sound culture to the public in public spaces. To address these issues, this study was designed to address the following research questions: What kind of design model should be constructed when sound is the main form of cultural connotation? How can an interactive installation be designed according to this model? In an open public environment, the users' evaluation of the installation is very important [10]. As such, how would the public rate the attractiveness of the interactive installation? Could the interactive installation contribute to cultural sustainability?

2. Related Works

2.1. Public Art Design and Sound Interaction

Public art design requires the public to actively participate in and direct the composition of the artwork [11]. It aims to evoke and capture the viewer's inner world and to resonate with it [12]. Studies have shown that interactive displays can encourage and stimulate social interaction and adapt to the surrounding environment, increase the public's engagement [13,14], and promote an attractive and positive urban environment [15]. Many artists and researchers have constantly experimented with and explored channels of artistic expression for public display design [13,16]. The transformation from analog display to digital display has enabled dynamic interaction and multimedia display to be better and to be displayed more quickly in public spaces [17]. Large-screen digital displays are quite common in public spaces such as subway stations, shopping malls, and airport terminals. As a result, the public has gradually lost their curiosity and attraction for such screen interactions [18]. Therefore, it is worth considering how to design public art to revive the public's interest and curiosity.

Many researchers have tried to use a combination of public design and interaction design to arouse public interest and to further promote the dissemination of culture. Kim et al. [19] studied the application of digital technology for the sustainability of South Korea's intangible cultural heritage. They applied VR technology to display aspects of intangible culture, proving that public design improved the quality of communication while reducing the threshold of audience acceptance. Podara et al. [20] designed an interactive documentary on cultural heritage. Their experimental results showed not only that this type of documentary was able to attract the attention of the public, but also that it could reach a wider audience. Tzima et al. [21] developed a storytelling system for children related to intangible cultural heritage. The system could be used as an effective teaching tool to stimulate children's interest in culture and increase their participation in class. In summary, the combination of public design and interactive design could effectively improve public participation and contribute to the sustainable development of culture.

Public interaction design tends to implement user interaction at the visual level, but the use of sound as a design subject is rare. Sound art is often used in some exhibitions, museums, and galleries [10] as a means of displaying works. Compared to the above exhibition scenes, the environments of other public places are more complex and uncertain, making it more challenging for art installations with sound as the interactive medium to have expressive and other special functions [22]. Therefore, this study attempted to find a way to combine a way through which traditional culture could be displayed publicly and interactive sound art could be experienced organically. We needed to explore the intrinsic value of traditional culture in a non-visual form and use modern technology to provide culture an opportunity to integrate into public life.

2.2. Contemporary Social Orientation of Guqin Culture

The Guqin belongs to the Guzheng family and is one of the oldest stringed and plucked instruments among traditional Chinese musical instruments [23]. It has evolved over the past 3000 years, with its shape, ideology, and culture constantly changing and developing, gradually becoming a unique part of the imagery and lifestyle of ancient literati [24]. The Guqin, one of the four major activities through which ancient literati cultivated sentiment and expressed feelings (among which are music, chess, calligraphy, and painting), has become the essence of Chinese music [23]. In November 2003, the Guqin was selected as part of the second batch of Representative Works of Human Oral and Intangible Cultural Heritage by UNESCO, which meant that the Guqin culture has been recognized and valued as a representative of Chinese traditional culture around the world. However, it also indicated that Guqin culture is declining and has become one of the aspects of heritage that needs to be protected.

Jianzi notation, which was invented by Rou Cao during the Tang Dynasty, is a unique Guqin notation [25]. It consists of a sequence of notations. Each notation is composed of a character for left- and right-handed techniques. Jianzi notation comprises a whole Chinese character (e.g., "一 二 三 四 五 六 七") or part of a Chinese character (e.g., "凵") [26]. According to the ancients, "if there is extension and contraction, it can be in tune", and "it can be slightly increased or decreased", indicating that the flexible rhythm manipulated by Jianzi notation is quite free. Nowadays, with the popularity of staff and simplified notation, Jianzi notation is even less known.

In the era of digital information, Guqin culture is also facing new challenges in terms of sustainable development, which lacks ancient cultural soil and a popular basis [25]. Since Guqin culture has become a minority culture in contemporary society, using modern technology might be an effective way for the public to become informed about this culture or even learn it. Specifically, the arrangement and re-creation of Guqin music might be a sustainable way through which this sound culture can be preserved. To solve this problem, this study tried to introduce Guqin culture into an interactive public installation. Guqin sound was used as an interactive element to create a unique interactive experience for the public through the fusion of visual modeling and auditory feeling.

2.3. Research Framework

Some scholars have performed product design and interaction design research and have constructed several design models for the purposes of achieving cultural sustainability. Leong and Clark proposed the "spatial perspective" of culture and divided culture into a framework with three levels, the outer "tangible" level, the middle "behavioral" level, and the inner "intangible" level [27]. Wu et al., further supplemented the model and proposed a physical/material layer, consumer behavior/ritual/customs layer, and ideal/spirit layer [28]. Lin combined cultural objects and design features and put forward the Cultural Product Design Model, which summarizes the cultural product design process into three phases, i.e., a conceptual model, a research method, and a design process [29]. In a word, the above studies on cultural levels and designs started from considering culture from a macro perspective but lacked differentiation study between specific cultural elements.

Especially for traditional culture whose cultural connotation is mainly expressed through sound, which is the focus of the present study, it was necessary to establish a directional and systematic research model based on previous grand culture research models.

Under the pressure of economic globalization and social transformation, cultural creative industries need to maintain the sustainability of traditional culture through design creativity [9]. On one hand, design is a driving force for cultural development that requires designers to take social needs into account to convey cultural connotations from the perspective of cultural characteristics [29]. On the other hand, culture requires more public participation to ensure its sustainability [19]. Therefore, our model develops cultural sustainability from both designer and public perspectives. On the basis of the "spatial perspective" of culture [27] and the Cultural Product Design Model [29], this study proposes a Public Sound Interaction Design Model based on Guqin culture. As shown in Figure 1, we divided the model into three levels, i.e., the "Physical and Tangible" level, the "Practical and Behavioral" level, and the "Metaphysical and Intangible" level. Each level has different meanings for both the designers and the public. For the designers, the "Physical and Tangible" level corresponds to the excavation of the characteristics of various cultural elements, i.e., the "Cultural Characteristics" stage; the "Practical and Behavioral" level corresponds to grasping social needs, i.e., the "Social Needs" stage; and the "Metaphysical and Intangible" level corresponds to the understanding of cultural connotation, i.e., the "Cultural Connotation" stage. For the public, the "Physical and Tangible" level corresponds to the "Feeling" level, the "Practical and Behavioral" level corresponds to the "Creation" level, and the "Metaphysical and Intangible" level corresponds to the "Share" level.
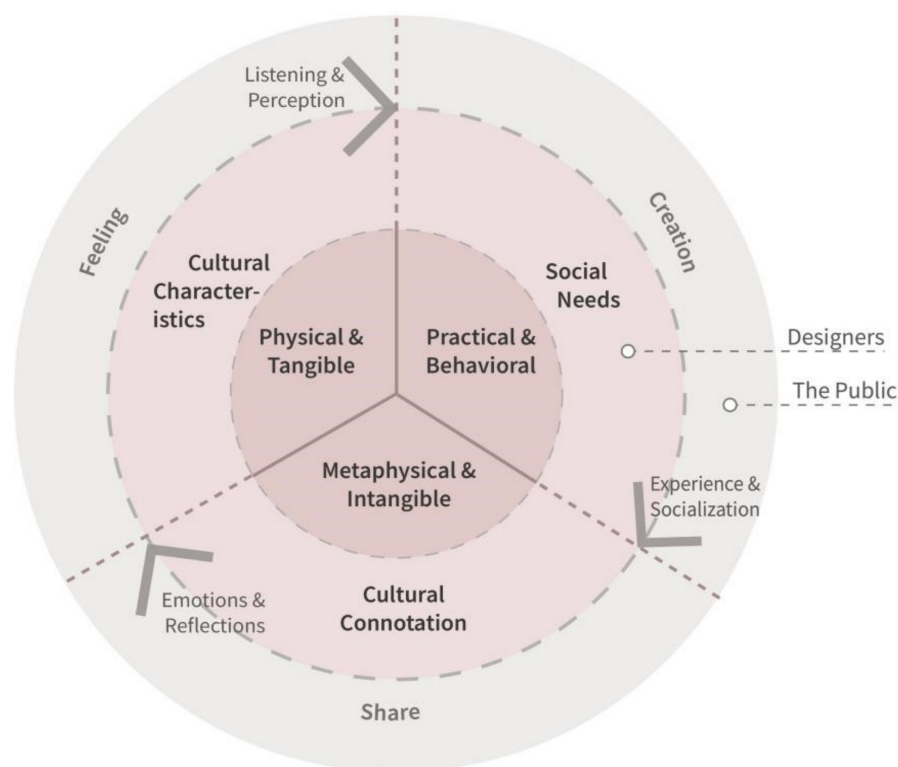

Figure 1. Public Sound Interaction Design Model based on Guqin culture.

There are circular relationships between the three levels. Each level serves the ultimate purpose of promoting culture sustainability. For the designers, the cultural characteristics are the source of design elements. Based on the cultural characteristics, the designers can explore social needs and clarify the purpose of design. The completed design needs to present the cultural characteristics from the spiritual level to reflect the cultural connotation. For the public, the "Feeling" level and the "Creation" level are connected by listening and perception. The public listens to the sound of the Guqin, becomes in touch with the relevant

knowledge of Guqin culture, and perceives the cultural atmosphere. The "Creation" level and the "Share" level are connected by experience and socialization, where the public touches the pattern of the Guqin board, understands Jianzi notation, and creates music while experiencing the Guqin interactive installation. The "Share" level and the "Feeling" level are connected by emotion and reflection, where the public feels the charm of the traditional musical instrument, shares the spiritual connotation of Guqin culture with others over the Internet, and attracts other people to experience Guqin culture, beginning a new cycle.

In order to verify the feasibility of the design model, we designed an interactive installation based on the model for verification. The interactive installation was be designed according to the perspective of the designers of the model. After the design was completed, some participants were be invited to experience the interactive installation and to evaluate it from perspective of the public.

3. Materials and Methods

3.1. Conceptual Design of the Interactive Installation

Before designing the installation, we investigated several existing Guqin mobile applications to identify the aspects of Guqin form, usage, and culture used in their design. Guqin mobile applications mainly include Guqin tuners, which provide real timbre sampling and proofreading functions for professional Guqin players and learners and can also be used to listen to Guqin music and display Guqin techniques. However, there were differences between the model developed this study and such mobile applications in terms of the research purpose and target group. The purpose of the installation design presented here was to publicize Guqin culture, make it more attractive and increase its visibility, and promote the sustainable development of Guqin culture. The target group was young people, who are the backbone of the future world. The acceptance and understanding of traditional culture by groups of young people represents the spread and development of this culture in the coming decades.

Next, according to the designers' perspective in the proposed Public Sound Interaction Design Model, we completed the "element–concept–design" transformation [29]. In the "Cultural Characteristics" stage, we extracted the cultural characteristics of the Guqin, including the body shape and the music score. In the "Social Needs" stage, we proposed the design direction according to social needs and application environment. In the "Cultural Connotation" stage, we artistically processed the cultural connotation and transformed the above information into a design concept. In addition, the cultural characteristics of Jianzi notation were transformed into patterns for the interactive installation, as the use of Jianzi notation was too complicated for the public.

Finally, the design concept was further polished according to the three levels from the public perspective in the Public Sound Interaction Design Model.

- For the "Feeling" level, we attributed the basic element of the Guqin to the sound of the Guqin instrument. When interacting with the installation, the most direct feedback received from the installation was the sound emitted by the installation. Therefore, we set up the installation to emit a specific musical sound from the Guqin when the sensor in the installation received a corresponding signal. This was the simplest form of interaction. In addition, the shape of the installation was designed to look similar to that of a Guqin in order to intuitively reflect the Guqin element.
- For the "Creation" level, we set the interaction to be triggered by specific actions (e.g., blowing, pulling, plucking, tapping, clapping, shaking, etc.) and the feedback of the interaction to be Guqin sounds. Because each participant interacted with the installation differently, attributes such as the amplitude and pitch of the sound were also different, making each piece of music unique and unrepeatable. This makes the installation more interesting and more likely to resonate with others. For example, participants could discuss the creation of a particular piece of music with each other. We also hoped that the participants would take the initiative to understand the Jianzi

notation during the creation process. Therefore, we added elements of Jianzi notation in the body of the installation so that the participants would pay attention on the Guqin-related cultural elements during the experience.

- For the "Share" level, we wanted the interactive installation to encourage participants to spontaneously record and share the "Feeling" and "Creation" experience. Participants could feel specific emotions during the experience and then share the recorded sound and his/her feelings with other participants through the Internet. The interactive scene could also attract potential participants within the same environment. Participants in this session would allow the cultural connotation of the Guqin to be spread.

Figure 2 shows the results of the conceptual design. The overall shape of the design was quite in line with the basic style of the Guqin. Figure 2a shows a conceptual rendering, in which the body of the installation was designed to be made of wooden boards. Figure 2b shows the patterns of the installation. The Jianzi notation was designed to be carved on the board via laser engraving. We expected this to help to guide the public to actively explore and understand the Guqin culture, which is conducive to cultural propaganda being present in the public space. In terms of usage, a public interactive art installation should be difficult for the majority of people to use and experience. However, playing the Guqin requires certain skills, increasing the difficulty of learning how to play it and experiencing the installation. Therefore, we adopted the "stringless playing" method, which would not only lower the threshold of public experience, but also enhance the interactive experience.
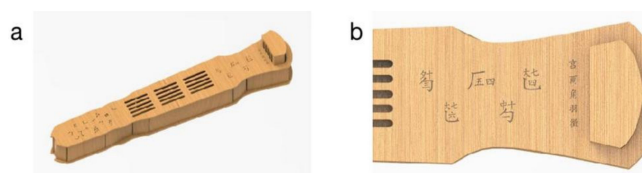

Figure 2. Conceptual design of the Guqin interactive installation: (**a**) Rendering of the Guqin interactive installation; (**b**) pattern of the Jianzi Notation.

3.2. Prototype of Interactive Installation

Based on the conceptual design, we prototyped the installation. Figure 3 shows the wiring diagram of the prototype. We constructed a prototype using an Arduino control board (model: Arduino Mega 2560 Pro), an infrared distance sensor (model: Sharp GP2Y0A02YK0F Infrared Distance Sensor), an MP3 module (model: Voice Box MP3 Module), and a speaker (30 levels of volume adjustment; optional sampling rates include 8/11.025/12/16/22.05/24/32/44.1/48 kHz). The Arduino board was the control center, which was connected to an infrared distance sensor as an external signal input device and an MP3 module as a signal output execution device. The infrared distance sensor could detect the distance between the sensor itself and an obstacle. The speaker was connected to the MP3 module, allowing it to emit sound. Guqin music was pre-recorded and stored on a memory card in the MP3 module. When the infrared sensor received an external signal, the signal was transmitted to the Arduino board. The Arduino board calculated the detection distance and then retrieved the corresponding Guqin music from the MP3 module according to the calculation results, controlling the speaker to emit sound.

- For the "Feeling" level, participants could listen to Guqin sound emitted by the interactive installation.
- For the "Creation" level, participants were free to create Guqin music. The infrared distance sensor detected the participant's behavior by detecting the distance between the sensor itself and the participant's finger. Since Guqin sound is divided into five scales, i.e., "gong", "shang", "jiao", "zhi", and "yu", we used five infrared distance sensors corresponding to the five scales and recorded three different tones for each scale.

That is, a total of 15 tones were pre-stored in the MP3 module. When the participants waved their fingers, the Arduino board controlled the speakers to emit continuous Guqin sounds of different tones based on the distance signals that were constantly being received. Therefore, the installation realized the "stringless playing" method.

- For the "Share" level, we surveyed whether the participants would take out their mobile phones to take photos and videos and share the Guqin music that they composed themselves and the creative experience with others to spread Guqin culture.
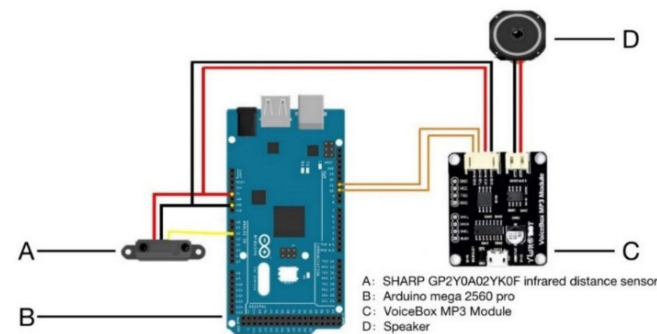

A: SHARP GP2Y0A02YK0F infrared distance sensor
B: Arduino mega 2560 pro
C: VoiceBox MP3 Module
D: Speaker

Figure 3. Wiring diagram of the prototype.

Figure 4 shows the finished prototype. We plugged the wiring components into the wooden shell of the installation. The overall shape of the interactive installation was close to that of a Guqin and Jianzi notation printed on the body. The installation was 825 mm long, 130 mm wide, and 70 mm high, similar to the proportions of a real Guqin (about 1200 mm long and 200 mm wide). The installation was equipped with five infrared distance sensors in place of the Guqin strings to achieve the "stringless playing" method. The infrared distance sensors measured the distance between the finger and the sensor itself and triggered different tones. Each string could trigger three tones, with triggering distances of 20–28 cm, 30–38 cm, and 40–48 cm. The sound level of the installation was about 70 dB and the emission frequency spectrum was about 1 kHz, which was also a parameter that could be clearly identified by the human ear. Overall, the installation was quite easy for the public to operate.
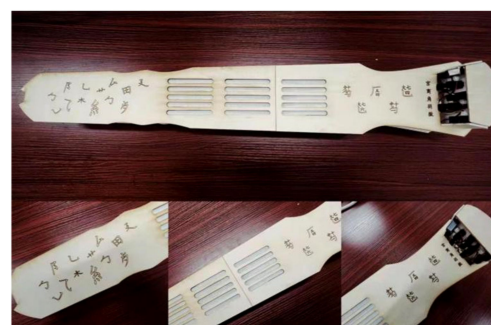

Figure 4. Prototype of the interactive Guqin installation.

3.3. Evaluation Methods

A user experience evaluation was used to verify whether the installation could attract the public and promote Guqin culture. The evaluation involved a revised Social Connectedness Scale (SCS-R) and an attractiveness assessment (AttrakDiff) [30]. The SCS-R was a set of psychometric scales that were used to assess the social connectedness between the participants and the evaluation object (the interactive installation). The higher the SCS-R score, the stronger the sense of social connectedness the installation had [31]. AttrakDiff was used to measure the attractiveness of the interactive installation using groups of antonymous adjectives, and the evaluation results were presented in a model diagram. This tool has

been used by DVAG, BMW, and other companies for product evaluation purposes [32]. The groups of antonymous adjectives were mainly distributed in four dimensions [33]:

- Pragmatic quality (PQ): When using the product or software, action objectives should be provided by useful and usable functions.
- Hedonic quality identity (HQ-S): This category focuses on the need to improve one's own knowledge and skills as well as natural curiosity.
- Hedonic quality stimulation (HQ-I): This includes the communication of other relevant self-serving messages.
- Attractiveness (ATT): This is the global positive or negative evaluation of a product or software, such as whether it is good or bad.

As shown in Table 1, the SCS-R questionnaire was divided into three levels according to the Public Sound Interaction Design Model. The AttrakDiff questionnaire was conducted on the attrakdiff.de website, in which the adjectives in groups 1–7 corresponded to PQ, groups 8–14 corresponded to HQ-I, groups 15–21 corresponded to HQ-S, and groups 22–28 corresponded to ATT [32].

Table 1. SCS-R questionnaire.

Level	Item
Feeling: Listening and Perception (Physical and Tangible)	1. I often hear Guqin music in my life. 2. I often come into contact with Guqin-related elements in my life.
Creation: Experience and Socialization (Practical and Behavioral)	3. I understand the appearance and types of Guqin. 4. I understand the Guqin music notation (letter notation, Jianzi notation). 5. I understand how to play the Guqin. 6. I understand the fingering of the Guqin.
Share: Emotions and Reflections (Metaphysical and Intangible)	7. I like listening to the music played by the Guqin. 8. I often listen to the music played by traditional Chinese musical instruments in my life. 9. I would like to share the music I hear played on traditional Chinese musical instruments with others. 10. I think the cultural and spiritual connotations of traditional Chinese musical instruments (and the music they play) appeal to me. 11. If there is a chance, I would like to experience an interactive installation based on the traditional Guqin.

3.4. Experiment and Procedure

This experiment invited college students to experience the interactive Guqin installation. Since the installation had the property of emitting sound, we set the location range of the installation in public spaces without noisy traffic, such as parks, squares, shopping malls, museums, etc. We set the formal location for the experiment in a square of a university campus, representing a public space with a sound level of about 53–57 dB. Since the sound level of the interactive installation was about 70 dB, it was reasonable to conduct the experiments in this environment. During the formal experiment, besides those who were invited to participate, many college students who were passing by were attracted by the interactive installation and participated actively in the experiment. We informed them that we would record the experiment process in pictures and videos. The experimental information shown below was all authorized by the participants.

During the experiment, we provided the installation to the participants and informed them of how to use the installation. Then, the participants were free to experience the installation. As shown in Figure 5, the participants consciously felt the physical elements of the installation (e.g., touching the board, listening to the sound) and played music freely. They could take out their phones to record videos, communicate with each other, and share with others. After the experience, the participants were invited to fill out the questionnaire mentioned above and to conduct a semi-structured interview.

○ represents the person being tested
● represents the test staff

Figure 5. Experiment of the interactive Guqin installation experience.

4. Results

In the SCS-R survey, a total of 168 participants (76 males, 92 females) filled out the questionnaire, with 57 participants filling out the questionnaire after experiencing the interactive installation. There were 44 participants who had experience using a Guqin tuner mobile application, and 67 of the participants had not had interaction with either the installation or a mobile application. In the AttrakDiff survey, a total of 51 participants filled out the questionnaire after experiencing the installation.

This study adopted homogeneous reliability (Cronbach's alpha coefficient) to examine the reliability of the questionnaire. The results show that the reliability coefficient value of the SCS-R was 0.892 (Cronbach's $\alpha > 0.8$), and the reliability coefficient of AttrakDiff was 0.936 (Cronbach's $\alpha > 0.8$). The reliability indexes of both questionnaires met the psychometric requirements and had good reliability.

4.1. Evaluation of Guqin Interactive Installation

Figure 6 clearly shows the results of the AttrakDiff questionnaire in four dimensions. The PQ values (1–7) indicate that the interactive Guqin installation reached the pragmatic quality user experience criteria. The HQ-I values (8–14) were also above 0, which means that the installation basically met the requirements for the participants' hedonic quality. There were many high values in HQ-S (15–21), indicating that the participants had higher demands for the content and interaction methods of the installation. The ATT values (22–28) were all above average, indicating that the participants rated the installation positively in terms of its attractiveness. In a word, most of the participants evaluated the Guqin interactive installation positively, proving that the installation presented here, designed based on the Public Sound Interaction Design Model, was attractive to the public.

The semi-structured interview provided further understand of the psychology of the participants by clarifying their feelings after experiencing the installation. The following is a list of things that the participants mentioned in the interviews:

"I feel that this music is very charming." This participant had never been exposed to a Guqin or other music-related expertise in the past. The installation stimulated the participant's interest and initiated a desire to understand Guqin culture.

"I learned about the form of the musical score of the Guqin through the installation. I think the Jianzi notion is a very unique way of recording music. We have to admire the creativity of our ancestors." This participant highlighted Jianzi notion. This was the purpose of adding the Jianzi notation elements to the pattern of installation; we hoped that this would arouse the participants' curiosity and encourage them to take the initiative to learn more about the Guqin.
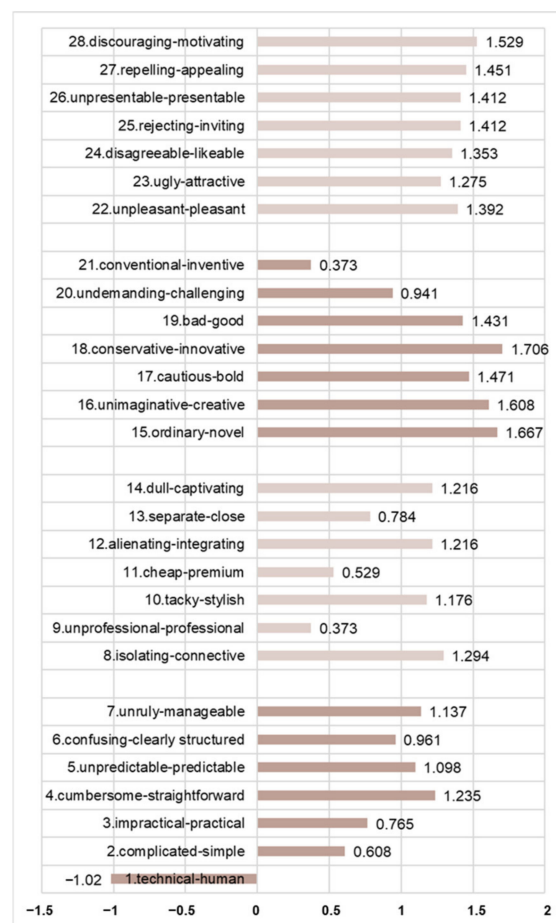
Figure 6. Results of the AttrakDiff questionnaire.

"I think the installation is very meaningful. First of all, you have done a good job in the basic work, making this interactive installation in the public space to let the public can understand some basic knowledge about traditional Chinese musical instruments. The interactive method is very easy to understand, even for people who have not studied music. Secondly, the contemporary public knows a lot about western musical instruments, while our traditional instruments do not receive as much attention as they should. Your installation can make the public pay attention to the Guqin to a certain extent. Finally, the installation can be further improved in terms of interface and interactive experience, and made into a commercialized toy or creative device, which will gain more audiences." The participant affirmed our efforts and put forward comments and suggestions for our work. As the participant mentioned, the contemporary public has paid more attention to foreign culture while ignoring local culture, which is detrimental to cultural heritage and development. The installation addressed this problem directly, combining traditional musical instruments with interactive technology to make traditional culture more attractive.

4.2. Comparative Analysis of Experience

To explore the effect of the interactive Guqin installation on the participants' cognition of Guqin culture, a one-way ANOVA was performed. The participants who had no experience were classified into group A (67 participants), those with installation experience were classified into group B (57 participants), and those with mobile application experience were classified into group C (44 participants). Table 2 shows the results of the ANOVA. With the exception of items 1, 2, and 8, there were significant differences between all three groups; $p < 0.05$.

Table 2. Results of one-way ANOVA.

Group	Item	Average Value	Standard Deviation	F	*p*	Item	Average Value	Standard Deviation	F	*p*
A		2.70	1.33				3.55	1.36		
B	1	2.89	1.48	1.549	0.216	7	4.16	1.15	3.891	0.022 *
C		2.45	0.63				3.77	1.03		
A		2.48	1.17				3.24	1.43		
B	2	2.84	1.49	1.704	0.185	8	3.70	1.66	1.586	0.208
C		2.45	0.97				3.43	1.20		
A		2.28	1.25				3.45	1.16		
B	3	3.40	1.07	17.036	0.000 **	9	4.33	1.12	8.699	0.000 **
C		2.39	1.04				3.84	1.27		
A		1.85	1.02				3.90	1.13		
B	4	2.32	1.18	3.656	0.028 *	10	4.54	1.14	4.809	0.009 **
C		1.91	0.71				4.05	1.35		
A		2.34	1.23				4.04	1.25		
B	5	3.16	1.11	8.680	0.000 **	11	4.68	1.00	4.526	0.012 *
C		2.43	1.09				4.23	1.34		
A		1.84	0.98				31.67	9.56		
B	6	3.32	1.18	28.961	0.000 **	Total Score	39.35	8.93	12.339	0.000 **
C		2.30	1.13				33.20	7.64		

Note: * $p < 0.05$; ** $p < 0.01$.

The LSD post hoc results are shown in Table 3. With the exception of items 1, 2, and 8, the scores of group B were significantly higher than those of group A on all other items; $p < 0.05$. Moreover, for items 3–6, 9, and 10, the scores of group B were also significantly higher than those of group C; $p < 0.05$. This shows that the participants who had experienced the installation had a significantly higher degree of social connectedness to Guqin culture than those who had no experience and who had only experienced a mobile application. The differences could be divided into two main levels, i.e., the "Practical and Behavioral" level (understanding the basic physical properties and playing method of the Guqin) and the "Metaphysical and Intangible" level (interest in and enthusiasm for sharing Guqin culture). This indicates that the interactive installation could highlight the physical properties of the Guqin better (item 3—appearance; item 4—notation; item 5—play; item 6—fingering) than the mobile application and that the installation made the participants more willing to share Guqin culture. In a word, the installation presented here and that was designed based on the Public Sound Interaction Design Model could have a positive effect on improving the influence of Guqin culture.

Table 3. Results of LSD post hoc analysis.

Contrast Groups	Item	Average Difference	*p*	Item	Average Difference	*p*	Item	Average Difference	*p*
A–B		−0.193	0.391		−0.815	0.000 **		−0.886	0.000 **
A–C	1	0.247	0.309	5	−0.089	0.693	9	−0.393	0.087
B–C		0.440	0.080		0.726	0.002 **		0.492	0.039 *
A–B		−0.364	0.106		−1.480	0.000 **		−0.648	0.003 **
A–C	2	0.023	0.924	6	−0.460	0.031 *	10	−0.150	0.518
B–C		0.388	0.122		1.020	0.000 **		0.498	0.039 *
A–B		−1.120	0.000 **		−0.606	0.006 **		−0.639	0.004 **
A–C	3	−0.103	0.642	7	−0.220	0.349	11	−0.183	0.434
B–C		1.017	0.000 **		0.385	0.115		0.457	0.059
A–B		−0.465	0.012 *		−0.463	0.080		−7.679	0.000 **
A–C	4	−0.058	0.766	8	−0.148	0.603	Total Score	−1.533	0.375
B–C		0.407	0.047 *		0.315	0.282		6.146	0.001 **

Note: * $p < 0.05$; ** $p < 0.01$.

4.3. Validation Analysis of the Design Model

To verify the feasibility of the Public Sound Interaction Design Model based on Guqin culture, an exploratory factor analysis and a confirmative factor analysis were performed on the SCS-R questionnaire.

The results of the exploratory factor analysis show that the KMO value was 0.872 and that the Bartlett's spherical test statistic was 1065.352; $p < 0.001$. This indicates that the questionnaire data were well suited for information extraction. The results of factor analysis show that all 11 items could be retained and that there were three factors in total. The dimensions of the factors were consistent with expectations, corresponding to the "Physical and Tangible", "Practical and Behavioral", and "Metaphysical and Intangible" levels. The variance explanation rates of the three factors were 26.663%, 26.043%, and 22.320%, respectively, and the cumulative variance explanation after rotation was 75.027% > 50%. These results indicate that the information of these items could be effectively extracted.

Then, confirmative factor analysis was performed. The results of the factor-loading coefficients are shown in Figure 7. The absolute values of the standardized loading coefficients of each correlation were greater than 0.6, indicating that there was a good measurement correlation. As shown in Table 4, the square-root values of the average variance extracted (AVE) of factor 1, factor 2, and factor 3 were 0.881, 0.795, and 0.757, respectively, all of which are greater than 0.5, indicating that the analyzed data had good aggregation validity. In addition, the three square-root values of AVE were also greater than the maximums of the absolute values of the inter-factor correlation coefficients, at 0.553, 0.490, and 0.553, respectively, implying that the analyzed data had good discriminant validity.
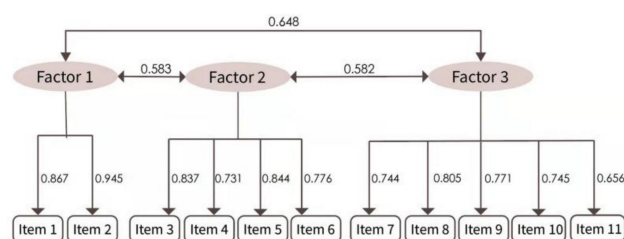

Figure 7. Results of the confirmative factor analysis.

Table 4. Results of discriminant validity.

	Factor 1	Factor 2	Factor 3
Factor 1	**0.881**		
Factor 2	0.490	**0.795**	
Factor 3	0.553	0.457	**0.757**

Note: Diagonal bold numbers are AVE square-root values and the rest are correlation coefficients.

In summary, the Public Sound Interaction Design Model that was developed based on Guqin culture corresponded well with the experimental data, proving that a model based on Guqin culture is feasible.

5. Discussion

This study aimed to construct a sustainable development design model for traditional culture whose main cultural connotation is expressed through sound. The experimental results show that the interactive installation designed according to the design model was evaluated well in the present experiment, verifying the feasibility and effectiveness of the design model. The existence of the interactive installation also enabled the participants to understand the charm of Guqin culture and be willing to share it with others, extending the spread of the culture at the social level. In addition, more interactive installations could be produced based on this design model, which could create a new path towards sustainable development for traditional culture.

5.1. Theoretical Implications

At present, many cities have issued programmatic policy documents focusing on sustainable cultural construction. Culture is recognized as a source of building sustainable development, creativity, and renewal [34]. The document said to "place culture at the heart of future policies for sustainable development." During the Convention for the Safeguarding of the Intangible Cultural Heritage, the importance of cultural heritage as a mainspring of cultural diversity and a guarantee for sustainable development was emphasized [35]. The design model and research method proposed in this study provided a theoretical basis for the implementation of these policies and convention documents.

Cultural sustainability requires public participation. Culture and society are interconnected, and sustainability requires a high level of human participation in terms of both cognition and action [36]. The realization of cultural sustainability also reflects the participation and equity of consumers in culture and design [37]. In the design model proposed in this study, all three levels require public participation. How the public evaluates the installation also affects the effectiveness of cultural transmission and cultural sustainability. The root cause of the predicament faced by intangible cultural heritage is not only related to itself, but is also closely related to the public [38].

The design model proposed in this study aimed to explore how to present the Guqin to the public in the form of sound interaction in a public space to broaden the communication channel of Guqin culture. In the model, the "Physical and Tangible" and "Practical and Behavioral" levels focused on the participation of individuals, with the aim of allowing individuals to experience culture and thus participate in cultural transmission. The "Metaphysical and Intangible" level aimed to shift the subject of cultural transmission from the individual to society. Therefore, this level required the power of the collective to form a consensus in favor of the preservation of traditional culture in society. The results of this study showed that most of the participants had a strong ability to recognize traditional culture. The installation could effectively attract their attention, improve their participation in traditional culture, stimulate their desire to share cultural elements, and make them become a medium for cultural propaganda. It provided new ideas for the promotion of the sustainable development of traditional culture.

The model should be free and needs to be redesigned according to the characteristics of the specific culture in which is used. The existence of pre-determined and additional conditions could have an adverse impact on cultural freedom and development [39]. The planned participation method used here was mainly to ensure that the experience resonated with the participants, allowing the public to actively participate in the development of new service systems and knowledge sharing [40]. Therefore, the design criteria of each cultural level of the model were also not fixed and need to be changed according to the cultural characteristics and audience needs.

5.2. Practical Implications

Education is an important means of transmitting culture. Sustainable cultural education indicates that culture should be considered in a broad and diverse way [41]. When a real carrier of traditional culture (e.g., a real Guqin) cannot be displayed, interactive installations could be used as substitutes to be shown and experienced. Moreover, the use of interactive installations enhances the public's aesthetic cognition and cultural confidence, allowing the traditional culture to gain more attention from the public. Based on this understanding, college students were invited to participate in the experiment. As representatives of a younger segment of the population, exploring their interest in and evaluation of the installation represents the possibility and necessity of such products in the future. In addition, college students are usually at the forefront of fashion and technology and are more tolerant of new things than other older age groups. This means that their opinions on the installation would be more targeted. In the experiment, the college students mentioned that the installation allowed them to reacquaint themselves with Guqin culture, indicating

that the method used in the present study was conducive to young people's understanding of traditional culture.

Integrating cultural elements into business is another means of promoting cultural sustainability. Cultural institutions and cultural policymakers usually address cultural sustainability by collaborating and producing new service products [40]. For example, the Palace Museum designed and sold creative cultural products based on the cultural relics in the museum that are very popular with consumers [9]. With the development of interactive technology, interactive art has gained popularity and consumption in business. Google Art and Culture has provided museums and exhibitions with high-definition images of artworks and virtual tours with 360-degree panoramic video, helping visitors have a better tour experience [42]. The British Museum created a digital learning center that used interactive devices to provide guided tours and exhibits for experiencers. The system helped experiencers get more timely feedback and resulted in many positive comments [43]. Overall, the public had high traditional culture consumption recognition [9]. These interactive devices enable the public not only to appreciate the objects but to also actually feel and experience them through communication and interaction in a comfortable and enjoyable environment, thus increasing the motivation and durability for learning [19]. The mode of "cultural relics exhibition + cultural and creative products + cultural art installation" has formed a sustainable model from cultural ontology and cultural derivatives to create cultural immersion experiences. Apart from these benefits, it has also resulted in cultural publicity, creating an organic development cycle for culture and commerce. Successful commercial applications show that traditional culture in the modern era can also contribute to market-oriented goals, such as accommodating the needs of new audiences and developing a collective creativity to achieve innovation [37].

6. Conclusions

This study proposed a Public Sound Interaction Design Model based on Guqin culture and designed an interactive Guqin installation that was based on the model. The experimental analysis shows that the model presented here based on Guqin culture is feasible and that the installation that was designed based on the model was attractive. In summary, this study could play a positive role in improving the influence of Guqin culture and realizing the sustainable transmission and development of traditional culture mainly in the form of sound.

The organic combination of traditional culture with design art and technology has been a necessary path to inherit and promote traditional culture in the present day. Traditional culture provides inspiration for design art and a landing platform for technology. In addition, design art can help traditional culture become better integrated into the public, and technology provides traditional culture vitality in the modern era.

There are also some deficiencies in this study. The experiment participants were college students, and the sample size was small, which might limit the universality of the results. In addition, different experimental environments would have an impact on the perception of the cultural atmosphere. Therefore, we expect to expand the scope of participants and to select a variety of environments in future studies.

References

1. Axelsson, R.; Angelstam, P.; Degerman, E.; Teitelbaum, S.; Andersson, K.; Elbakidze, M.; Drotz, M.K. Social and cultural sustainability: Criteria, indicators, verifier variables for measurement and maps for visualization to support planning. *Ambio* **2013**, *42*, 215–228. [CrossRef] [PubMed]
2. Kuhlman, T.; Farrington, J. What is sustainability? *Sustainability* **2010**, *2*, 3436–3448. [CrossRef]
3. Lin, J.; Cai, J.; Han, Y.; Zhu, H.; Cheng, Z. Culture sustainability: Culture quotient (CQ) and its quantitative empirical application to Chinese cities. *Sustainability* **2016**, *8*, 1235. [CrossRef]
4. Loach, K.; Rowley, J.; Griffiths, J. Cultural sustainability as a strategy for the survival of museums and libraries. *Int. J. Cult. Policy* **2017**, *23*, 186–198. [CrossRef]
5. Kurin, R. Safeguarding intangible cultural heritage in the 2003 UNESCO convention: A critical appraisal. *Mus. Int.* **2004**, *56*, 66–77. [CrossRef]
6. Yang, Y.; Shafi, M.; Song, X.; Yang, R. Preservation of cultural heritage embodied in traditional crafts in the developing countries. A case study of Pakistani handicraft industry. *Sustainability* **2018**, *10*, 1336. [CrossRef]
7. Jiang, Y.; Li, D.; Cang, S. Integration of card board games design and traditional culture. *Art Res. Lett.* **2014**, *3*, 18–24. [CrossRef]
8. Qin, Z.; Ng, S. Culture as inspiration: A metaphorical framework for designing products with traditional cultural properties (TCPs). *Sustainability* **2020**, *12*, 7171. [CrossRef]
9. Tu, J.C.; Liu, L.X.; Cui, Y. A study on consumers' preferences for the Palace Museum's cultural and creative products from the perspective of cultural sustainability. *Sustainability* **2019**, *11*, 3502. [CrossRef]
10. Birchfield, D.; Phillips, K.; Kidané, A.; Lorig, D. Interactive public sound art: A case study. In Proceedings of the New Interfaces for Musical Expression, NIME-06, Paris, France, 4–8 June 2006.
11. Hein, H. What is public art?: Time, place, and meaning. *J. Aesthet. Art Crit.* **2002**, *54*, 1–7. [CrossRef]
12. Sharp, J.; Pollock, V.; Paddison, R. Just art for a just city: Public art and social inclusion in urban regeneration. *Urban Stud.* **2005**, *42*, 1001–1023. [CrossRef]
13. Brignull, H.; Rogers, Y. Enticing people to interact with large public displays in public spaces. In Proceedings of the Human-computer Interaction Interact 03: IFIP TC13 International Conference on Human-computer Interaction, Zurich, Switzerland, 1–5 September 2003.
14. Rogers, Y. Moving on from Weiser's vision of calm computing: Engaging Ubicomp experiences. In Proceedings of the International conference on Ubiquitous computing, Orange County, CA, USA, 17–21 September 2006; Springer: Berlin/Heidelberg, Germany, 2006; pp. 404–421.
15. Veenstra, M.; Wouters, N.; Kanis, M.; Brandenburg, S.; Moere, A.V. Should public displays be interactive? Evaluating the impact of interactivity on audience engagement. In Proceedings of the International Symposium on Pervasive Displays, Saarbruecken, Germany, 10–12 June 2015.
16. Jenkins, H. Confronting the challenges of participatory culture: Media education for the 21st century. *Educ. Gerontol.* **2008**, *29*, 617–626. [CrossRef]
17. Müller, J.; Alt, F.; Michelis, D.; Schmidt, A. Requirements and design space for interactive public displays. In Proceedings of the 18th International Conference on Multimedea 2010, Firenze, Italy, 25–29 October 2010.
18. Nisi, V.; Jorge, C.; Nunes, N.; Hanna, J. Madeira story generator: Prospecting serendipitous storytelling in public spaces. *Entertain. Comput.* **2016**, *16*, 15–27. [CrossRef]
19. Kim, S.; Im, D.U.; Lee, J.; Choi, H. Utility of Digital Technologies for the Sustainability of Intangible Cultural Heritage (ICH) in Korea. *Sustainability* **2019**, *11*, 6117. [CrossRef]
20. Podara, A.; Giomelakis, D.; Nicolaou, C.; Matsiola, M.; Kotsakis, R. Digital Storytelling in Cultural Heritage: Audience Engagement in the Interactive Documentary New Life. *Sustainability* **2021**, *13*, 1193. [CrossRef]
21. Tzima, S.; Styliaras, G.; Bassounas, A.; Tzima, M. Harnessing the Potential of Storytelling and Mobile Technology in Intangible Cultural Heritage: A Case Study in Early Childhood Education in Sustainability. *Sustainability* **2020**, *12*, 9416. [CrossRef]
22. Franinovic, K.; Visell, Y. New musical interfaces in context: Sonic interaction design in the urban setting. In Proceedings of the Proceedings of the 7th International Conference on New Interfaces for Musical Expression, New York, NY, USA, 6–10 June 2007; pp. 191–196.

23. Leman, M.; Desmet, F.; Styns, F.; Van Noorden, L.; Moelants, D. Sharing musical expression through embodied listening: A case study based on Chinese Guqin music. *Music Percept.* **2009**, *26*, 263–278. [CrossRef]
24. Nathanson, D.H. Dao De Qin: A Case Study of the Guqin. 2012. Available online: https://digitalcollections.sit.edu/isp_collection/1344 (accessed on 22 January 2022).
25. Wang, S. A brief description of the rhythmic notation of the Guqin Jianzi Notation. *Art Rev.* **2021**, *2*, 4–8.
26. Chen, G. Overview of digital protection of Guqin art and intelligent analysis of temperament. *J. Fudan Univ.* **2019**, *58*, 335–342. [CrossRef]
27. Leong, B.D.; Clark, H. Culture-based knowledge towards new design thinking and practice—A dialogue. *Des. Issues* **2003**, *19*, 48–58. [CrossRef]
28. Wu, T.Y.; Hsu, C.H. The study of Taiwan aboriginal culture on product design. In Proceedings of the Futureground-DRS International Conference, Melbourne, Australia, 17–21 November 2004.
29. Lin, R.-T. Transforming Taiwan aboriginal cultural features into modern product design: A case study of a cross-cultural product design model. *Int. J. Des.* **2007**, *1*, 45–53. [CrossRef]
30. Feng, W.; Hu, J.; Funk, M. Practice and experience evaluation of interactive digital public art design. *Zhuangshi Chin. J. Des.* **2015**, *9*, 96–97. [CrossRef]
31. Lee, R.M.; Draper, M.; Lee, S. Social connectedness, dysfunctional interpersonal behaviors, and psychological distress: Testing a mediator model. *J. Couns. Psychol.* **2001**, *48*, 310–318. [CrossRef]
32. Hassenzahl, M.; Burmester, M.; Koller, F. AttrakDiff: Ein fragebogen zur messung wahrgenommener hedonischer und pragmatischer qualität. In *Mensch & Computer 2003*; Springer: Berlin/Heidelberg, Germany, 2003; pp. 187–196.
33. Strckl, D.; Oberrauner, E.; Krainer, D.; Wohofsky, L.; Oberzaucher, J. Hedonic and pragmatic qualities of AAL pilot region technologies: Evaluation with the AttrakDiff Survey. In Proceedings of the ICT4AWE-6th International Conference on Information and Communication Technologies for Ageing Well and e-Health, Prague, Czech Republic, 3–5 May 2020.
34. UNESCO. The Hangzhou Declaration Placing Culture at the Heart of Sustainable Development Policies. 2013. Available online: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CLT/images/FinalHangzhouDeclaration20130517.pdf (accessed on 6 February 2022).
35. UNESCO. Convention for the Safeguarding of the Intangible Cultural Heritage. 2003. Available online: https://ich.unesco.org/en/convention (accessed on 6 February 2022).
36. Soini, K.; Dessein, J. Culture-Sustainability relation: Towards a conceptual framework. *Sustainability* **2016**, *8*, 167. [CrossRef]
37. Murphy, K. The social pillar of sustainable development: A literature review and framework for policy analysis. *Sustain. Sci. Pract. Policy* **2012**, *8*, 15–29. [CrossRef]
38. Zhuang, L.; Hong, T. Research on the conservation strategy of intangible cultural heritage based on consumer preference. *Ethn. Art Res.* **2010**, *5*. [CrossRef]
39. Mpofu, P. The dearth of culture in sustainable development: The impact of NGOs' agenda and conditionalities on cultural sustainability in Zimbabwe. *J. Sustain. Dev. Afr.* **2012**, *14*, 191–205.
40. Luisa, E.; Roberto, M. Leveraging smart open innovation for achieving cultural sustainability: Learning from a new city museum project. *Sustainability* **2018**, *10*, 1964. [CrossRef]
41. Laine, M. Culture in sustainability—Defining cultural sustainability in education. *Discourse Commun. Sustain. Educ.* **2016**, *7*, 52–67. [CrossRef]
42. Google. Google Arts & Culture. Available online: https://artsandculture.google.com/explore (accessed on 6 February 2022).
43. The British Museum. Samsung Digital Discovery Centre. Available online: https://www.britishmuseum.org/learning/samsung_centre.aspx (accessed on 6 February 2022).