education sciences

From Hi-Tech to Hi-Touch

A Global Perspective of Design Education and Practice

Edited by

Rungtai Lin, Po-Hsien Lin, I-Ying Chiang and Ching Chiuan Yen

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From Hi-Tech to Hi-Touch: A Global Perspective of Design Education and Practice

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Contents

About the Editors . . . . . **vii**

Rungtai Lin, Po-Hsien Lin, I-Ying Chiang and Ching-Chiuan Yen
From Hi-Tech to Hi-Touch: A Global Perspective of Design Education and Practice
Reprinted from: *Educ. Sci.* **2023**, *13*, 314, doi:10.3390/educsci13030314 . . . . . **1**

Yikang Sun, Po-Hsien Lin and Rungtai Lin
From Data to Wisdom: A Case Study of OPOP Model
Reprinted from: *Educ. Sci.* **2021**, *11*, 606, doi:10.3390/educsci11100606 . . . . . **7**

I-Ying Chiang, Po-Hsien Lin, John G. Kreifeldt and Rungtai Lin
From Theory to Practice: An Adaptive Development of Design Education
Reprinted from: *Educ. Sci.* **2021**, *11*, 673, doi:10.3390/educsci11110673 . . . . . **25**

Yikang Sun, Chien-Chih Ni and Yen-Yu Kang
Comparison of Four Universities on Both Sides of the Taiwan Strait Regarding the Cognitive Differences in the Transition from STEM to STEAM in Design Education
Reprinted from: *Educ. Sci.* **2023**, *13*, 241, doi:10.3390/educsci13030241 . . . . . **43**

Chi-Sen Hung, Tien-Li Chen and Yun-Chi Lee
From Cultural Heritage Preservation to Art Craft Education: A Study on Taiwan Traditional Lacquerware Art Preservation and Training
Reprinted from: *Educ. Sci.* **2021**, *11*, 801, doi:10.3390/educsci11120801 . . . . . **59**

Rungtai Lin, I-Ying Chiang, Yuma Taru, Yajuan Gao, John G. Kreifeldt, Yikang Sun and Jun Wu
Education in Cultural Heritage: A Case Study of Redesigning Atayal Weaving Loom
Reprinted from: *Educ. Sci.* **2022**, *12*, 872, doi:10.3390/educsci12120872 . . . . . **73**

Wen-Ting Fang, Jian-Hua Sun, Pei-Hao Tong and Yen-Yu Kang
A Teaching Model of Cultural and Creative Design Based on the Philosophy of the *Book of Changes*
Reprinted from: *Educ. Sci.* **2023**, *13*, 120, doi:10.3390/educsci13020120 . . . . . **93**

Tien-Li Chen, Yun-Chi Lee and Chi-Sen Hung
A Study on the Effects of Digital Learning Sheet Design Strategy on the Learning Motivation and Learning Outcomes of Museum Exhibition Visitors
Reprinted from: *Educ. Sci.* **2022**, *12*, 135, doi:10.3390/educsci12020135 . . . . . **117**

Hui-Jiun Hu
The Design and Implementation of an Innovative Course on the Creation of Cultural Landscape Images: A Case Study of Dalin Township in Taiwan
Reprinted from: *Educ. Sci.* **2023**, *13*, 36, doi:10.3390/educsci13010036 . . . . . **147**

Chia-Ling Chang, Chin-Lon Lin, Chi-Hsien Hsu and Yikang Sun
From Digital Collection to Open Access: A Preliminary Study on the Use of Digital Models of Local Culture
Reprinted from: *Educ. Sci.* **2023**, *13*, 205, doi:10.3390/educsci13020205 . . . . . **173**

Yi-Wen Ting, Po-Hsien Lin and Chih-Long Lin
The Transformation and Application of Virtual and Reality in Creative Teaching: A New Interpretation of the *Triadic Ballet*
Reprinted from: *Educ. Sci.* **2023**, *13*, 61, doi:10.3390/educsci13010061 . . . . . **191**

Chun-Yuan Chen, Po-Hsien Lin, Yen-Yu Kang and Chih-Long Lin
The Global Design Ranking: A Case Study of Design Awards Phenomenon
Reprinted from: *Educ. Sci.* **2023**, *13*, 113, doi:10.3390/educsci13020113 . . . . . **205**

About the Editors

Rungtai Lin

Rungtai Lin is a Professor in the Graduate School of Creative Industry Design, National Taiwan University of Arts, Taipei, Taiwan. He was the Chairman of Taiwan Design Center, (2012–2018), and was also President of the Mingchi Institute of Technology, Taipei, Taiwan (1996–2002), and Chang Gung Institute of Technology, Tao-Yuan, Taiwan (2002–2003). He received his M.S. and Ph.D. degree in Engineering Design at Tufts University, MA, USA, in 1988 and 1992. Lin authored numerous publications, authored or co-authored over 200 papers, and presented over 100 papers at professional conferences throughout the world. His research interests are in Ergonomics in Product Design, Human–Computer Interaction, Design Education, and Cognitive Approach in Design. Recently, his research has been involved in Cultural and Creative Product Design.

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I-Ying Chiang

As an artist, designer and educator, I-Ying Chiang is currently a professor in the Department of Arts and Design at National Tsing Hua University, Taiwan. For decades, she has engaged in cultural product design, creative industries, contemporary jewelry design, metalsmithing, and craftwork creation. She sees this endeavor as an accord between body and time reached through a process of dialectical interaction. In both concept and technique, her creation is a fusion of tradition and innovation, in which she earnestly examines the relationship between time and existence. She also enhanced her artwork and design teaching by merging technology and humanity, which also tried to expand the scope of craft and design to broaden categories. Chiang strives to maintain a poetic balance between academic accuracy and creative ingenuity on her bi-track of reason and emotion.

Ching-Chiuan Yen

A/Prof YEN Ching Chiuan is the Co-Director of the Keio-NUS CUTE Center, Deputy Director of NUS Centre for Additive Manufacturing (AM.NUS) and was the founding Head of Division of Industrial Design (DID) at the National University of Singapore (NUS). He also holds joint appointments with the Smart Systems Institute and Centre for Additive Manufacturing (AM.NUS) at NUS. His research interests lie in methodologies for design, and he champions a "pluralistic dimension" of design study and research, in particular, in the area of design for healthcare and medicine. He has worked with many renowned companies including: ABBOT, ASUS, BMW Designwork USA, Coca Cola, Creative, Chang Gung Memorial Hospital, DELL, Estee Lauder, OSIM, National University Hospital, Samsung, Swarovski, Tupperware, VISA, etc. He has successfully received over SGD 30M grant as PI/Co-PI/Collaborator from government agencies, universities, and industries. His supervision in design is highly regarded and has received more than 50 top international or regional design awards, including, to name a few, the Stanford Longevity Technology Prize 2015, Braunprize 2007, Luminary, red-dot award: design concept 2006, ACM CHI Student Competition 2016, and James Dyson Award (Singapore) 2012.

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Editorial

From Hi-Tech to Hi-Touch: A Global Perspective of Design Education and Practice

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1. Introduction

Facing the change in and impact of globalization, the question of how to apply design thinking to improve people's lives, from hi-tech to hi-touch, is becoming increasingly vital during this disquieting era. This Special Issue aimed to discuss the development, application, potential and boundaries of design education and design practice from a cross-cultural perspective [1]. Thus, we welcomed both theoretical research via a careful literature review with various design scopes and empirical studies of significant design cases.

Potential topics included, but were not limited to:

- Frameworks for design education that foster creativity and critical thinking;
- Significant teaching and learning sequences of design;
- Theoretics and practice within design education approaches;
- Design education across disciplines;
- Teacher training for design;
- Design implementation for cross-culture contexts;
- Research on creative design strategies;
- Design for placemaking;
- Special topics in design case studies.

2. Results and Discussion

The Special Issue entitled "From Hi-Tech to Hi-Touch: A Global Perspective of Design Education and Practice" published in *Education Sciences* comprises eleven scholarly papers classified into four categories. The first category includes three papers that examine the practical application of design theory in different contexts. The second category comprises three papers exploring the role of technology in design education. The third category includes three papers that analyze the intersection of design education and cross-cultural communication. The final category encompasses two papers investigating the application of design education in diverse fields.

Collectively, these papers provide a comprehensive overview of the current state of design education. They also highlight the diversity of approaches and practices within the field. By offering valuable insights into the challenges and opportunities present in various contexts, they demonstrate the significance of design education as a facilitator of creativity, innovation and cross-disciplinary collaboration.

2.1. From Design Theory to Design Practice

The first category of articles contains three papers which examine the relationship between design theory and design practice. These papers investigate how design theories

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can be applied to practical design solutions. They stress the significance of design thinking and the problem-solving role of designers. They also highlight the need for design educators to teach students how to apply design theories to real-world scenarios. These papers offer valuable insights into how design theory can be integrated into design education and how it can be leveraged to generate effective design solutions.

2.1.1. Contribution 1: From Data to Wisdom: A Case Study of OPOP Model

In this article, the OPOP model [2] based on the DIKW process (Data, Information, Knowledge, and Wisdom) was proposed. This model provided a framework for turning data into actionable insights. In the paper, a case study that applies the OPOP model to identify and address issues related to academic resource accessibility in a university context was presented. By using the model, in the study, the researchers were able to identify patterns in the data, which led to a better understanding of the problem and a strategic plan for improvement. The paper concluded by discussing the potential of the OPOP model for data-driven decision making and emphasized the importance of integrating data analysis with human-centered design principles.

2.1.2. Contribution 2: From Theory to Practice: An Adaptive Development of Design Education

In this article, an adaptive design education model to enhance students' readiness for real-world design practice was presented [3]. To develop the model, the authors synthesized the theoretical foundations of design education with insights from interviews with design practitioners. The paper also covered the implementation of the model in a design education program, its evaluation through student feedback and assessment, and its continuous refinement in response to feedback from students and practitioners. The authors highlighted the potential of adaptive design education to more effectively align with the needs of the design industry and prepare students for successful design careers. They also emphasized the significance of continuous evaluation and adaptation to ensure that design education remains relevant and effective in a rapidly changing context.

2.1.3. Contribution 11: Comparison of Four Universities on Both Sides of the Taiwan Strait Regarding the Cognitive Differences in the Transition from STEM to STEAM in Design Education

In this study, the aim was to assess perceptions of the STEAM model in design education among respondents from four universities on both sides of the Taiwan Strait [4]. The findings demonstrated that respondents' restricted global outlook is attributable to their exposure to local universities. Further analysis was warranted to ascertain the connection between art courses and STEM. To optimize the potential of STEAM in design education, educators and researchers must have a deep understanding of the essence and connotations of STEAM, while students should prioritize the acquisition of knowledge and skills relevant to 21st-century design through STEAM courses. The continuous assessment and refinement of STEAM in design education is also indispensable.

2.2. Education in Cross-Cultural Design

The second category of articles comprises three papers that center on education within the realm of cross-cultural design. These papers explore the challenges and opportunities of teaching design in multicultural contexts. They highlight the importance of cultural sensitivity in design education and provide insights into how design educators can create inclusive learning environments. The papers also examine how design education can advance intercultural understanding and collaboration.

2.2.1. Contribution 3: From Cultural Heritage Preservation to Art Craft Education: A Study on Taiwan Traditional Lacquerware Art Preservation and Training

The authors investigated the current state of traditional lacquerware art preservation and training in Taiwan [5]. Using a combination of a literature review, expert interviews and

field visits, in this study, several challenges for preservation and training were identified, including limited resources, difficulty transmitting traditional techniques, and declining interest in traditional arts and crafts. To address these challenges, the authors advocated a shift in focus from cultural heritage preservation to art craft education, suggesting the incorporation of lacquerware art into art and design education curricula. Specifically, they proposed the establishment of a national lacquerware art center, the development of marketing strategies, and the creation of a certification system for lacquerware products. The authors emphasized the importance of preserving traditional lacquerware art and the need for a shift in focus to ensure its survival. This study provided valuable insights and suggestions for preserving and cultivating traditional lacquerware art in Taiwan.

2.2.2. Contribution 5: Education in Cultural Heritage: A Case Study of Redesigning Atayal Weaving Loom

In this article, the authors examined the significance of education in cultural heritage preservation through a case study of the participatory design of the Atayal weaving loom in Taiwan [6]. In the study, it was identified that the participatory design process improved the functionality of the weaving loom and provided a platform for the transmission of traditional weaving knowledge and skills to younger generations. The authors proposed that education in cultural heritage should go beyond the preservation of artifacts and include the transmission of traditional knowledge and skills. The findings of this study provided valuable insights into the role of education in cultural heritage preservation and the potential of participatory design as a tool for preserving cultural heritage.

2.2.3. Contribution 9: A Teaching Model of Cultural and Creative Design Based on the Philosophy of the Book of Changes

In this article, a teaching model for cultural and creative design based on the philosophy of the *Book of Changes* was proposed [7]. In the paper, it was argued that the *Book of Changes* could provide a valuable framework for teaching, as its philosophy emphasizes the importance of balance, harmony and adaptability. In the article, a course developed using this teaching model that integrates traditional Chinese cultural elements into modern design practices was presented. In addition, the effectiveness of the course was evaluated, and the impact of the *Book of Changes* philosophy on the students' design thinking and creative processes was discussed. The paper concluded that the teaching model has the potential to enhance students' cultural awareness and creative abilities, and the model was recommended as a valuable addition to design education.

2.3. Informatic Communication Technology in Design

The third category of articles contains three papers examining the use of informatic communication technology in design education. These papers explore how technology can be used to enhance the design learning experience. They highlight the potential of new technologies, such as virtual and augmented reality, to provide students with new ways to explore design concepts and develop essential skills. The papers also examine how technology can be used to create authentic learning experiences for students.

The way ICT (Information and Communication Technology) is used in design education is becoming a design trend. In modern design, ICT is a useful support tool, as solutions can be created by using ICT effectively and efficiently. Using computer-based systems, such as virtual systems and computer simulations, ICT could be used to record ideas that clarify a task, generate and manage digital solutions in response to challenges arising from learning activities, clarify the creative intention, and respond to a need. This could make a design more powerful, effective and efficient.

2.3.1. Contribution 4: A Study on the Effects of Digital Learning Sheet Design Strategy on the Learning Motivation and Learning Outcomes of Museum Exhibition Visitors

The authors examined the relationship between digital learning sheet design and its effect on museum visitor motivation and learning outcomes [8]. In the study, museum visitors were divided into two groups. One received traditional learning sheets, while the other received digital ones with different design strategies. The findings showed that digital learning sheets with multimedia elements, interactivity, personalization and clear structures improved visitors' motivation and learning outcomes. By suggesting that museums incorporate these design strategies into their digital learning sheets to enhance visitor learning experiences, the findings of the study provided invaluable insights into the design of digital learning sheets and their impact on visitors' learning.

2.3.2. Contribution 6: The Design and Implementation of an Innovative Course on the Creation of Cultural Landscape Images: A Case Study of Dalin Township in Taiwan

In this article, a case study of an innovative course that aims to promote the creation of cultural landscape images in Dalin Township, Taiwan, was presented [9]. The course combined both theoretical and practical components, using diverse teaching methods to engage students and promote their participation. The course content, its teaching methods and the resulting outcomes for students were presented in the paper. It was concluded that the course successfully promoted the creation of cultural landscape images and enhanced students' understanding of the local cultural heritage. In the paper, it was proposed that the course could serve as a model for similar educational initiatives which have the aim of preserving cultural heritage and developing community.

2.3.3. Contribution 10: From Digital Collection to Open Access: A Preliminary Study on the Use of Digital Models of Local Culture

In the past, cultural content was protected passively. The emergence of new technologies such as digital printing and open-source sharing have provided new opportunities for cultural preservation [10]. This study focused on the Taitung region and created an open-source database consisting of 60 digital models and related materials. By sharing these resources openly, the aim of the study was to encourage wider use. The survey results demonstrated that models designed in parts that are easy to print and display are more useful for promotion and application. The aim was to develop 3D model databases for every township, providing people with free access to digital models of their local culture. This open-source approach enabled anyone to remotely access and print local cultural content in 3D, especially during the COVID-19 pandemic. The localized 3D model databases were expected to promote cultural improvement and innovation at the local level.

2.4. Other Fields

The last group of articles includes two papers that investigate the role of design education in various domains, such as in the fields of engineering and healthcare. They demonstrate how design thinking could address intricate problems in these fields and emphasize the importance of interdisciplinary collaboration.

2.4.1. Contribution 7: The Transformation and Application of Virtual and Reality in Creative Teaching: A New Interpretation of the Triadic Ballet

In this article, the use of virtual and augmented reality in creative teaching was explored, using *Triadic Ballet* [11] as a case study. A course where students used virtual reality technology to generate 3D models of the ballet's costumes and stage setup, which were then brought to life through the use of augmented reality, was outlined in the paper. The educational implications of this approach were examined, highlighting its potential to enhance students' creativity and critical thinking abilities. An in-depth evaluation of the students' work was also provided in the article, demonstrating the effectiveness of the approach in promoting interdisciplinary collaboration and innovation. Overall, the authors

claimed that the use of virtual and augmented reality could transform creative teaching and provide new opportunities for artistic expression and exploration.

2.4.2. Contribution 8: The Global Design Ranking: A Case Study of Design Awards Phenomenon

In this article, the phenomenon of design awards and their impact on the design industry were explored [12]. A case study of the Global Design Ranking system, which ranks design awards based on their level of influence and prestige, was presented. The methodology used to create the ranking was presented, and the data collected were analyzed to explore the trends and patterns in the design awards landscape. In addition, the potential impact of the ranking on the design industry was addressed in the paper, including its ability to shape the perception of design and influence the behavior of designers and design firms. Finally, avenues for future research in this area were suggested, such as the exploration of the relationship between design awards and design education.

3. Conclusions

The Special Issue published by *Education Sciences* is a significant contribution to the field of design education. The issue comprises a collection of articles that explore various aspects of design education, including the pedagogical approaches, the use of technology, and the role of design in addressing social and environmental challenges. This editorial paper provides a comprehensive review of the Special Issue and highlights the key themes that have emerged from the articles. The Special Issue offers invaluable insights into the latest pedagogical approaches, technologies and trends in the field of design education. It provides a rich and nuanced view of the challenges and opportunities faced by design educators today. It is an invaluable resource for researchers, educators and practitioners in the field of design education and is highly recommended.

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Article

From Data to Wisdom: A Case Study of OPOP Model

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Abstract: The purpose of this research is to: (1) clarify the scope and connotation of the OPOP (One Product/Project/Performance, One Paper) model comprehensively; (2) show its application in design and creative teaching; (3) introduce this model to more people. First, the author reviews the design doctoral education system and its shortcomings and analyzes the similarities and differences between "Ph.D. of Design" and "Master of Design"; second, the researcher discusses the DIKW (Data, Information, Knowledge, Wisdom) pyramid, cognition and communication theory separately. The author also interviewed the two teachers who created the OPOP model to clarify its core meaning and goals. Finally, the author invited students who participated in an OPOP forum to fill out a questionnaire in order to analyze and understand their responses and suggestions. The OPOP model allows participants to realize that "creativity" and "interpretation" are equally important and to gradually learn to use academic papers to transform personal "tips" and "experience" into "knowledge" that can be imparted. The author hopes that the OPOP model and the general frameworks mentioned in this study can inspire all readers, enabling them to continuously explore the connotation and further possibilities of OPOP in light of the actual situation.

Keywords: OPOP model; DIKW pyramid; creativity and interpretation; cognition and communication; design education; interdisciplinary

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1. Introduction

Design is a highly applied subject. Generally speaking, when a design is recognized by the market and consumers, it can gain profits for the company and gain prestige for the brand. For designers and manufacturers, in addition to ensuring the quality of the design and the appropriate price, how the interpretation of the design works for others is also very important. Even if a design is excellent, if its designer cannot effectively transmit the connotation of his work, it may not easily attract a consumer's attention.

Although the fields, goals, and potential audiences of different types of designs are different, they usually need to meet the criteria called "Good Design". At the same time, these designs also need to be as close as possible to their desired essence and goals [1–8]. However, consumers may not understand these slightly wordy guidelines which also require designers to use simpler, straightforward, and simple design language to pass on their design concepts and characteristics to others. Even if a product is functionally inadequate, if the people who see it can feel the story behind the design, a certain consensus can be formed between the designer and the user. It is likely to make this product more popular, because attractive things will make people feel better. The *Juicy Salif*, designed by Philip Stark, is perhaps one of the more successful cases of "interpretation" design [9]. As Starck stated: "My juicer is not meant to squeeze lemons; it is meant to start conversations [10]".

Therefore, for designers, in addition to mastering the basic skills and literacy of designing, they must also learn how to successfully sell their own designs; that is, how to pass their ideas clearly to others. It is hoped that, through the OPOP teaching model, students can develop research-based logical thinking and have the ability to effectively

convey the intention and connotation of their works. At the same time, the education and training of design patterns can also introduce the OPOP model because the doctoral education in the field of design focuses more on the training of logical thinking, and the ability to dig deeper and explore the essence of design.

The course of this study is as follows: first, the author reviews the design doctoral education system and its shortcomings and analyzes the similarities and differences between "Ph.D. of Design" and "Master of Design"; secondly, the researcher discusses the DIKW (Data, Information, Knowledge, and Wisdom) pyramid, cognition and communication theory separately. In order to clarify the core meaning and goals of the OPOP model, the author also presents the results of interviews with the two teachers who created it. Finally, the author invited students who participated in an OPOP forum to fill out a questionnaire in order to analyze and understand their responses and suggestions. The OPOP model allows participants to realize that "creativity" and "interpretation" are equally important and to gradually learn to use academic papers to transform personal "tips" and "experience" into "knowledge" that can be imparted. The purpose of this research is to: (1) clarify the scope and connotation of the OPOP model comprehensively; (2) show its application in design and creative teaching; (3) introduce this model to more people. The author hopes that the OPOP model and the general frameworks discussed in this study can inspire all readers, enabling them to continuously explore the connotation and more possibilities of OPOP in light of the actual situation.

2. Background

2.1. The Intention and Shortcoming the Doctoral Education of Design

When the social and economic level of a country or region has developed to a certain level, design education comes into being. Since the 20th century, the German model has always occupied a pivotal position in the global design field, forming the Bauhaus–Ulm System [11–16]. The German design education model has become the benchmark in many countries. Even though national conditions and cultures are different, the core part of the design education models, concepts, and theories in many countries and regions can be seen in the shadow of the "Bauhaus-Ulm System". In addition, some countries and regions in East Asia have also been affected by the Bauhaus trend, and their design education models generally follow the above-mentioned system [17–25].

Since the 20th century, with the advancement of technology, the history of design development can be roughly divided into five stages. Each stage can be described by an "F": (1) Design for Function in the 1930s; (2) Design for Friendly in the 1950s; (3) Design for Fun in the 1970s; (4) Design for Fancy in the 1990s; (5) Design for Feeling since the 21st century [26–28]. The core concept of modern design can be summarized into four main characteristics, namely: (1) "serving the most people" (the ultimate goal), (2) "Form follows Function" (core theory), (3) "Form follows Market" (realistic considerations) and (4) "Form follows Life" (deep experience). The model and content of design education have been continuously adjusted and expanded along with the development process which was mentioned (see Figure 1), and its importance is increasing day by day [29–35].

We believe that researchers need to understand the development pulse and laws of modern design, and need to firmly grasp the current and future design hot topics, which will help us construct a more suitable design education model.

For designers, they not only need to design a product that can solve practical problems and is easy to use, but also require the product (or service) to bring users a sense of pleasure and even a deeper experience. Most of the countries or regions where design development is relatively mature have experienced the development process from OEM (Original Equipment Manufacturer) to ODM (Original Design Manufacturer) and, then, to OBM (Own Branding and Manufacturing). In this regard, Lin, Kreifeldt, and Huang and Chen [36] centered on the trend of design development in Taiwan and put forward three trends of current and future design development: (1) From Function to Feeling; (2) From Use to User; (3) From High-tech to High-touch. That is, design has gone from "solving

problem" to the level of increasing taste and pleasure. Therefore, this requires designers to continuously improve their abilities, not only to master the skills of "making design", but also to have the concept of "interpreting". This also requires that the model of design education be constantly adjusted.

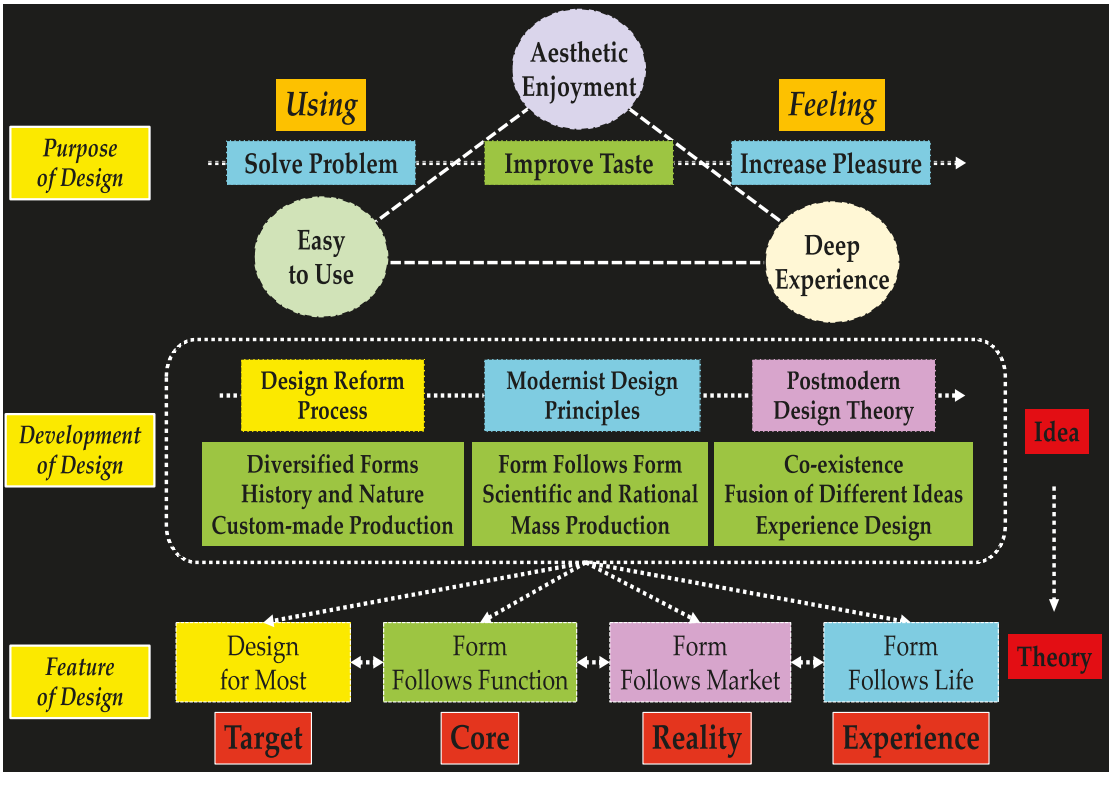

Figure 1. Thinking about the design education model from the perspective of the development process of modern design and its core concepts. (Source: this study.)

We are accustomed to using "Master of Design" to refer to designers who are achieving outstanding achievements. These masters focus on creation, and they also write books to explain and promote their design concepts. At the same time, there is also a group of scholars in universities or research institutions, among whom most have obtained or are about to obtain doctoral degrees, and who have developed critical thinking under systematic and professional training.

In the academic education of the arts major, the Master of Fine Arts (MFA) is the highest degree that students engaged in artistic creation can obtain. In recent years, many schools have begun to grant qualified students a Doctor of Fine Arts (DFA) or a Doctor of Philosophy degrees in the traditional sense. However, what is the purpose of doctoral education in design disciplines? Do people who are engaged in design practice have to take a Ph.D.? "Master of Design" and "Ph.D. of Design" are not comparable. If we must point out the difference between the two, the author believes that the former focuses on sharing with others their own tips and experiences, while the latter can transform them into knowledge, and then rise to a deeper level of wisdom.

2.2. The Development and Current Situation of Design Education in Taiwan

The Bauhaus movement has been the greatest influence on the design field in the 20th century. In general, the development of Taiwan's design education was followed the concept of the Bauhaus style. Prof. Lin, from one of the research teams, has conducted many researches on design education in Taiwan, and published them in journals and academic seminars [36–39]. Based on the above reasons, this section does not spend too much space to discuss design education in Taiwan, and the OPOP model is also proposed by Prof. Po-Hsien Lin and Prof. Rungtai Lin based on his thoughts on design education in Taiwan and the world.

From the perspective of Taiwan's design education system, many high schools and vocational schools have design-related departments. From the perspective of their curriculum settings, they are not much different from the first and second grades of university design departments. After 2 to 3 years of academic and technical training, these high school or vocational school students have all the skills needed to engage in design practice. In terms of actual experience and skills, they may be richer and more proficient than college students and graduate students. The author believes that studying in a university or graduate school should be more about the training and development of a thinking model, improving understanding from the "concept" level, and developing a mode of critical thinking.

The formulation of a major or subject teaching model is often through to consist of multiple demonstrations and experiments, with the principle that most students can adapt. Although some courses are taught in small classes, they still cannot be tailored specifically for each student. In other words, some of the course content and teaching methods may make some students uncomfortable. Even the courses of a graduate school may not all adopt the "one-to-one" teaching model. Therefore, in addition to the educator who can continuously improve and revise the content of the curriculum and the classroom model, students also need to know the crux of their own "unsuitability".

In summary, the teaching mode of design creativity needs to be continuously adjusted according to the development of design, and it also needs to better guide students. Teachers not only teach students basic skills, but more importantly, they also need to inspire students' ideas and concepts, and enable students to master effective methods, such as how to effectively interpret their designs and creativity. Especially in recent years, artificial intelligence has been involved in design creation [40]. Perhaps designers will not be unemployed in the short-term, but from the perspective of development trends, we need to master the ability to "interpret" design. Otherwise, it is easy to be eliminated by the times.

3. The Theoretical Framework and Methods

3.1. The DIKW Pyramid

Students and designers in the design field are often more willing to write design reports rather than articles. The reasons for this vary from person to person. The author believes that, apart from not mastering effective research methods, they may not be able to clarify the relationship between creation, design, and research. Knowledge is the tips and experience of the ancestors; it is the result of a systematic analysis, sorting, and research. It can be stated: "The value of tips is sharing, the value of experience is inheritance, and the value of knowledge is transmitting". Therefore, the value of research is to share the tips and turn them into experience which can be passed on and turned into knowledge which can then be imparted through analysis and induction.

Many professors work in the emerging research field of how to turn the creative process into knowledge that can be imparted. In the process of creation and design, we have accumulated a wealth of experience and knowledge. Why cannot they be transformed into knowledge that can be imparted through systematic research? Creation refers to the process of "coding" and "decoding" observation and experience of daily life which creators express in a new form. For creators, the theme of creation and the motivation behind it may be simple or complex. It is one of the means for creators to express their personal feelings and characteristics.

Research produces knowledge and knowledge is a tool that uses known theories to explain various phenomena in daily life. Research is the analysis of phenomena that cannot be explained by knowledge in daily life, and after theoretical verification, it becomes knowledge that can be learned. The purpose of the research is to find ways to find practical and feasible methods for problems that cannot be solved with existing knowledge, and to turn them into theoretical bases that can be copied or reused. The Massachusetts Institute of Technology (MIT) divides the ultimate goal of knowledge education into three levels—Reason, Knowledge, and Wisdom—, and fully expresses them in the curriculum [41]. On the other hand, "research, teaching, and service" is the teacher's duty, because research can generate knowledge, and the purpose of teaching is to spread knowledge. Finally, applying knowledge in practice can be called a service. The purpose of our research is to turn the original data into useful information through an analysis and synthesis; then, to analyze and summarize this information into useful knowledge. Finally, through teaching, the knowledge can be passed on and applied flexibly in daily life. The relationship between the teacher's duty (Research, Teaching, and Service) and the three levels of education goals (Reason, Knowledge, and Wisdom) are shown in Figure 2.

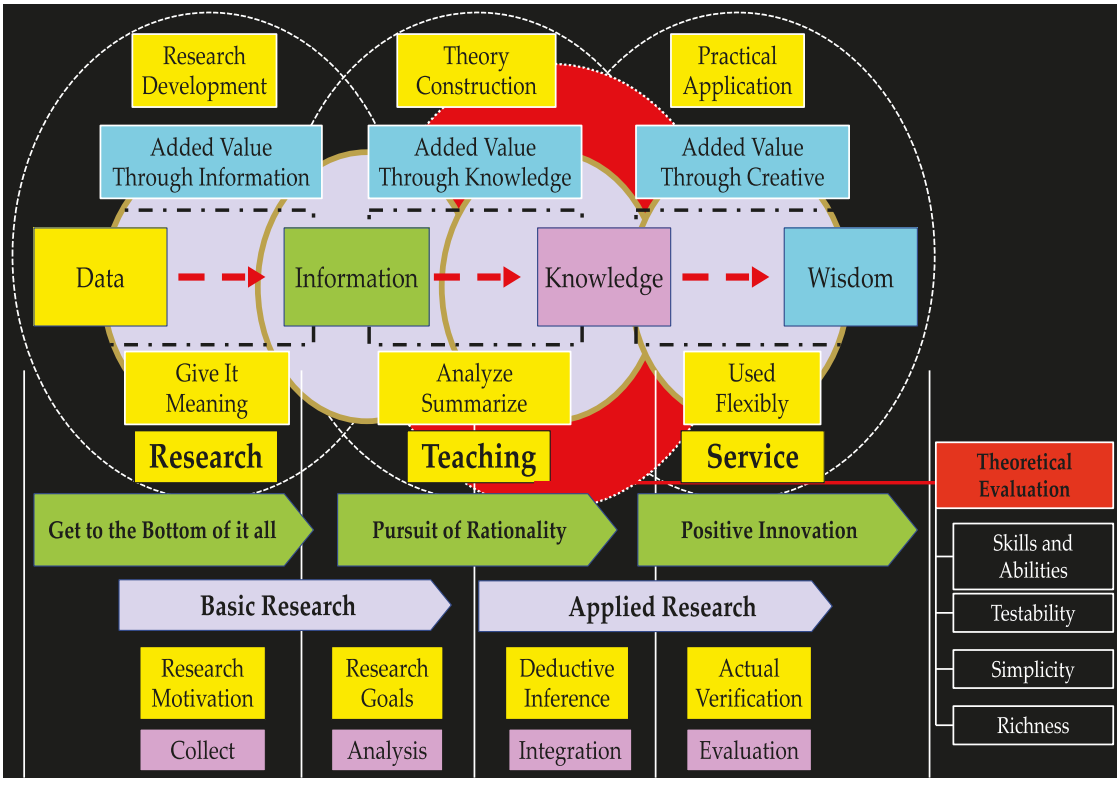

Figure 2. Research framework from Data to Wisdom. (Reprinted with permission from [42]. Copyright 2009 Lin, R. et al.)

3.2. Design Research: From Individual to General

The difference between creation and design may be considered from the purpose of creation. Different from applied art, the creation mentioned here focuses more on the level of appreciation and feeling. At this time, the motivation of creation may be very personal, and the so-called motivation may not even exist. It may just be a whim of the creator. Creators are often unwilling to follow the trend and be similar to others. Coupled with

many creative works, it may be just for appreciation. At this time, the creator does not have to consider various specific situations such as creating design. This may also be a certain characteristic contained in the broad sense of creation. Therefore, writing a creation into a paper is not only a case study, but also a sharing of tips and experience, and a process of "From Data to Wisdom" [43–45].

The question is, what kind of case studies can be written as articles and accepted and published by prestigious domestic and foreign journals? Articles are a kind of "Quasi-knowledge". Therefore, an excellent case study needs to be carried out using the DIKW system. Design is also a form of creation. In terms of modern design, it is a combination of sensibility (humanities and arts) and rationality (science and technology). It requires not only the spirituality and sensibility of artistic creation, but also the rigor and rationality of engineering and science when facing problems. For researchers, in order to explore whether there is a certain rule in creation, it is necessary to choose appropriate research methods to carry out corresponding research. As a result, it is possible to find a certain rule (abstract) or a certain pattern (concrete). The quality of creation should be an abstract, reproducible or reusable theoretical basis. If researchers can find out such internal laws, they are naturally happy. Tables 1 and 2 show the similarities and differences between different studies (such as articles, reports).

Table 1. The similarities and differences between academic articles, design creation reports, and creation reports.

Academic Articles	Design Creation Reports	Creation Reports
1. Literature Review 2. Theory Construction 3. Research Design 4. Results and Analysis 5. Discussion 6. Conclusions and Suggestions	1. Design Theory Discussion 2. Design Concept Construction 3. Exploration of the Way of Design and Design Method 4. Design Results and Analysis 5. Discussion Between Results, Ideas and Theories 6. Conclusions and Suggestions	1. Theoretical Foundation 2. Creative idea 3. Methods and Techniques 4. Content and Form 5. Artistic Value and Contribution

(Source: this study.)

Table 2. The similarities and differences between creation reports, creation papers, and academic articles.

Creation Reports	Create Papers	Create Papers	Create Papers	Academic Articles
1. Theoretical Foundation 2. Design Practice 3. Creative Review 4. Creative Experience	1. Theoretical Foundation 2. Design Practice 3. Creative Review 4. Creative Experience 5. Post Verification	1. Theoretical Foundation 2. Pre-study 3. Conclusions 4. Design Practice 5. Creative Review 6. Creative Experience	1. Theoretical Foundation 2. Pre-study 3. Conclusions 4. Design Practice 5. Creative Review 6. Creative Experience 7. Post Verification	1. Theoretical Foundation 2. Literature Review 3. Research Framework 4. Research Methods 5. Research Operations 6. Research Results 7. Research Findings

(Source: this study.)

Each case is a variable, and its context or background is different. The purpose of the case study, in addition to sharing experience and passing on experience, is focused on presenting the creative ingenuity and logical thinking of the case to solve the problem through a complete discussion. If the creativity of individual case-solving problems can be repeated, someone will sort it into a certain "principle" and, then, after verification, the "knowledge" will be formed. The cognitive model of "research" can be seen in Figure 3.

3.3. Methods

According to the research purpose, the researcher designed the interview content (see Appendix A), and invited two scholars who established the OPOP model to answer, so as to understand their motives and goals. At the same time, the researchers also invited some students who used the OPOP model, and asked them to talk about their recognition of the OPOP model based on their actual experience, and what else they think the OPOP model has to improve (see Appendix B).

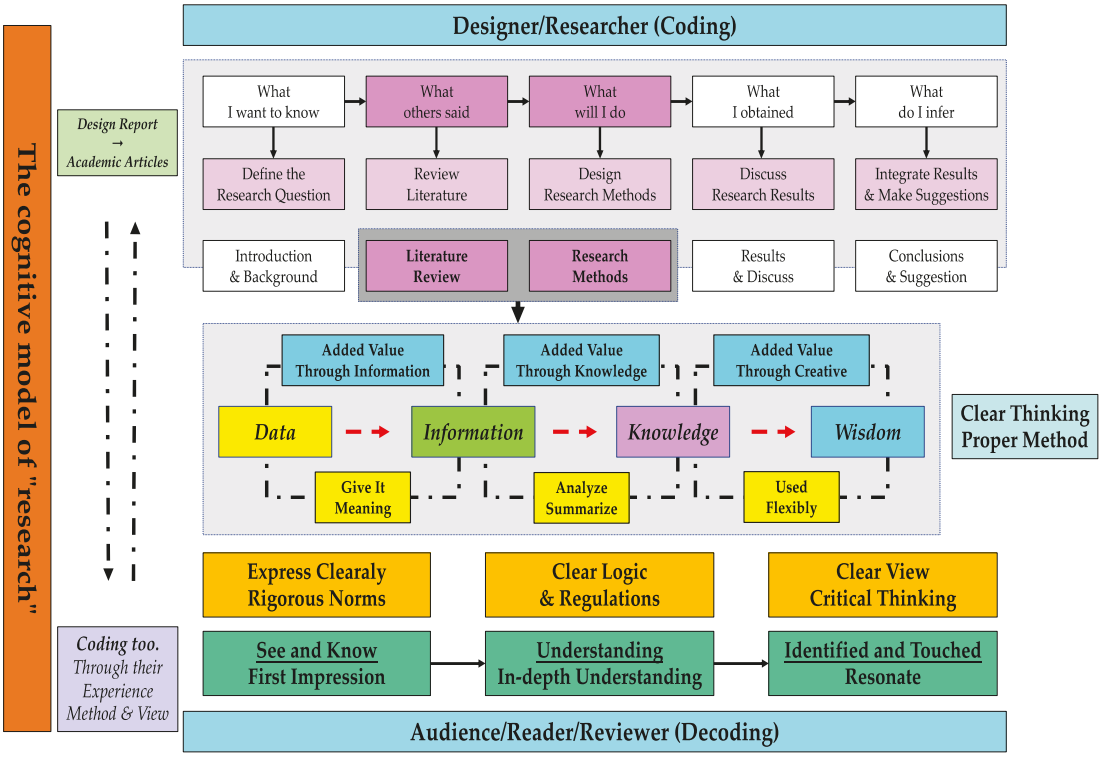

Figure 3. The cognitive model of "research". How to conduct research is an eternal topic. For students or researchers in the field of art and design, they prefer to create and write creation reports. In fact, even if it is a report on creation, how it lacks a scientific mode of thinking, it may not allow viewers to decode it correctly. From individual to general, this is exactly one of the goals that the OPOP model hopes to achieve. (Source: adapted from [33,34,42].)

Combining the opinions of experts and students, we further proposed future research ideas: we hope to continuously improve the OPOP model and extend it to more schools and departments (mainly in art, design, performance, and craft).

4. Case Study for Applying and Validation OPOP Model

4.1. The OPOP Model

The categories of design and education are immense; unlike fine arts, design is a highly practical subject, and needs to pay more attention to the market's demand, not just as an ornament. The development and education models of most countries and regions are mostly influenced by Bauhaus. However, the OPOP model introduces research-oriented thinking into the creation. It allows students to explore the deeper meaning behind the creation while creating, and use a scientific method to further turn the creation into an article. In this way, not only can more people understand the connotation behind the creation, but also the long-term separation between theory and practice can be brought closer. Compared with the traditional design education curriculum system and mode, the concept of OPOP is relatively new, and we hope to make OPOP become a kind of "inertial thinking".

The OPOP model tries to provide students and researchers in the field of design and creativity with a way of thinking: let them look at practice with a research-based thinking, so we did not specify a particular field, which is why the first "P" can be continuously extended. It can be a product, a performance, a project, and a plan, etc. From the purpose of

the establishment of the Graduate School of Creative Industry Design, the National Taiwan University of Arts (GSCID, NTUA) [46], we could clearly see the motivation and goal of the OPOP model-accumulating experience from "Cross-field Learning" to prepare for the future "Cross-border Service" (see Table 3). The author believes that, in the future, OPOP can be further promoted to the depth of "One Possibility, One Philosophy". Because the meaning of the second "P" in OPOP can be continuously extended, we believe that "One Possibility, One Philosophy" may be more representative at this stage. The OPOP model has been continuously improved and perfected, and we are confident to put forward new ideas in follow-up research.

Table 3. OPOP: From "Cross-field Learning" to "Cross-border Services".

Cross-Field Learning			Cross-Border Services		
One One	Performance Paper	→ Creative	One One	Ph. D Position	→ Position
One One	Project Paper	→ Industry	One One	Position Platform	→ Platform
One One	Product Paper	→ Design	One One	Platform Progress	→ Progress
One Possibility, One Philosophy					

In order to fully understand the connotation of OPOP, this study interviewed two OPOP model founders (see Appendix A) and randomly selected a dozen students who used the OPOP model to fill out a questionnaire (see Appendix B). Due to space limitations, three cases were selected below to help readers understand how to apply the OPOP model to different studies. The author believes that the OPOP model has extremely broad scalability and good applicability.

In the next section, we shared three articles involving a plan, product, and project. These articles applied the essence of the OPOP model flexibly to research.

4.2. Typical Cases

The Ph.D. students recruited by GSCID had diverse backgrounds, such as design, architecture, crafts, painting, and performance, which were also in line with the motivation of GSCID and the goals of the cross-disciplinary research. Since September 2018, the OPOP model has become an important part of the GSCID series of courses. This section randomly selected three articles from the research articles that made extensive use of the OPOP model (see Appendix C) to further explain to readers how the OPOP model was used as a general model. These three articles based on the OPOP model passed the peer review and were officially published in the international seminar. These authors accepted questions from scholars from different countries or regions at the seminar. Generally speaking, although these articles still deserved to be improved, they showed that the OPOP model is reliable to a certain extent.

Our intention was to explain to more readers how the OPOP model was used in different fields. Due to space limitations, for the details of these articles, interested readers are welcome to further consult the full version of these articles (their titles are shown in Appendix C). At the same time, we look forward to your feedback to us after reading these articles. This is very helpful for us to further improve the OPOP model!

4.2.1. Case 1: Museum and Cultural Products Co-Creation Brand Value: Taking the Innovative Cultural Products of Ningbo Port Museum as an Example (One Plan, One Paper)

Chang [47] used the Ningbo Port Museum as a subject to discuss the issue of creating brand value between museums and cultural products. Chang pointed out that, to a degree, the 21st century is emotional, the new art exhibition trend will be accompanied by the viewer/consumer's experience, and the viewer/consumer's expectations for the future,

consistent with the three connotations of culture, design, and marketing. Cultural products that conform to the museum's brand image could make the public more willing to return and pay attention to the pulse of the museum. Therefore, under the sharing and creation of the museum and its derivative cultural products, the museum can be endowed with brand value through a more attractive brand charm. In addition, museums that have a lot of room for development in creative industries can create more industries or service areas by enhancing brand value. In the article, the author constructed the museum cultural product brand derivation system (Figure 4), and the cultural innovation value-added design model from the cultural level to the design attributes (Figure 5), which provided a reference for research in related fields.

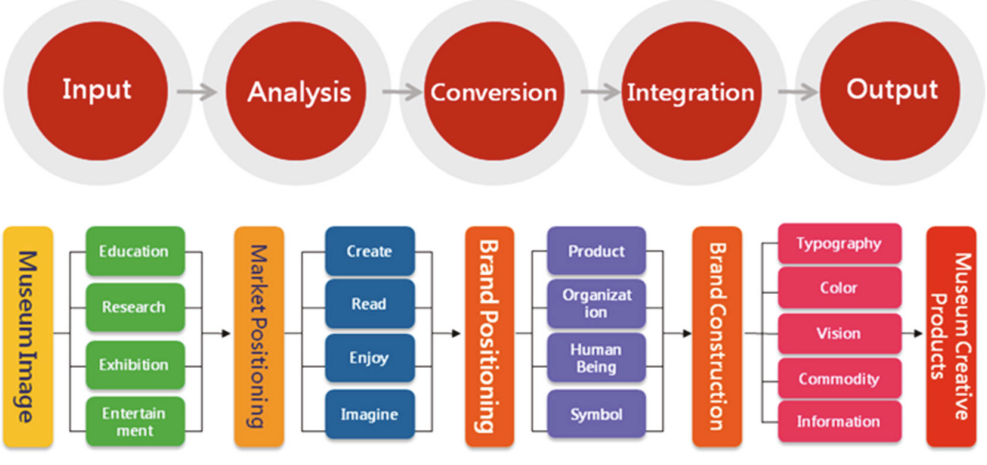

Figure 4. Museum cultural products brand derivative system. (Reprinted with permission from [47]. Copyright 2019 Chang.)

Figure 5. Cultural innovation value-added design model from the cultural level to design attribute. (Reprinted with permission from [47]. Copyright 2019 Chang.)

4.2.2. Case 2: A Study of Cultural Ergonomics in Atayal Weaving Box (One Product, One Paper)

How to combine traditional culture with modern design and construct a design model of cultural products has become a hot topic in recent years. Based on the previous studies, many scholars have conducted a series of related studies on this issue [48,49]. Kreifeld et al. [48] proposed a cultural ergonomic research model to provide designers with a valuable reference for designing a successful cross-cultural product as well as the interwoven experience of design and culture in the design process. They attempted to illustrate how, by enhancing the original meaning and images of Taiwan's aboriginal culture features, they may be transformed into modern products by taking advantage of new production technology, and so, fulfill the needs of the contemporary consumer market. They proposed a cultural ergonomic research model to provide designers with a valuable reference for designing a successful cross-cultural product as shown in Figure 6 [49].

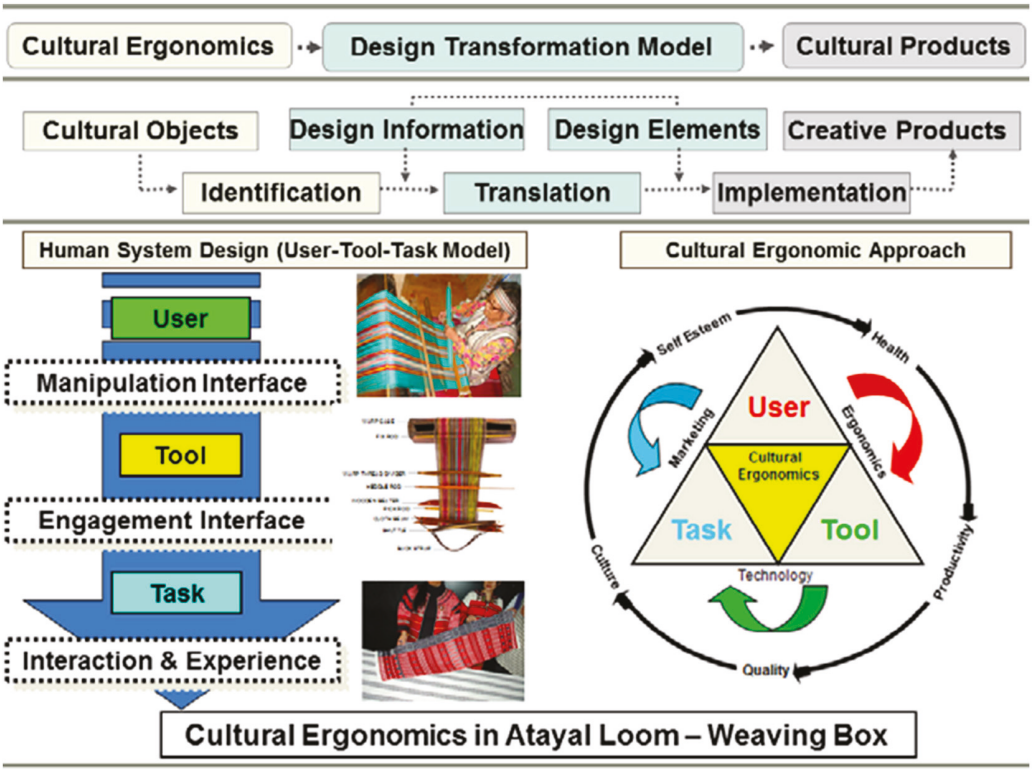

Figure 6. A cultural ergonomic research model in Atayal loom. (Reprinted with permission from [49]. Copyright 2016 Taru et al.)

4.2.3. Case 3: A Study of Japan's Welfare Beauty Service from Cultural Creative's Perspective (One Project, One Paper)

The concept of "service design" focuses on enterprise service planning and management. It also emphasizes systematic methods and customer-centric thinking. The population ageing problem has also attracted the attention of scholars in the field of design and creativity. Lin, Yen and Chen [50] shifted their focus from designing a specific product and planning a specific project to the current and important topic of population aging. At the same time, they found another way to explore the characteristics and advantages of Japanese welfare and beauty services from the perspective of cultural creativity. From

Figure 7, it is not difficult to see that they grasped the OPOP model and reorganized the relevant research structure according to specific research objects.

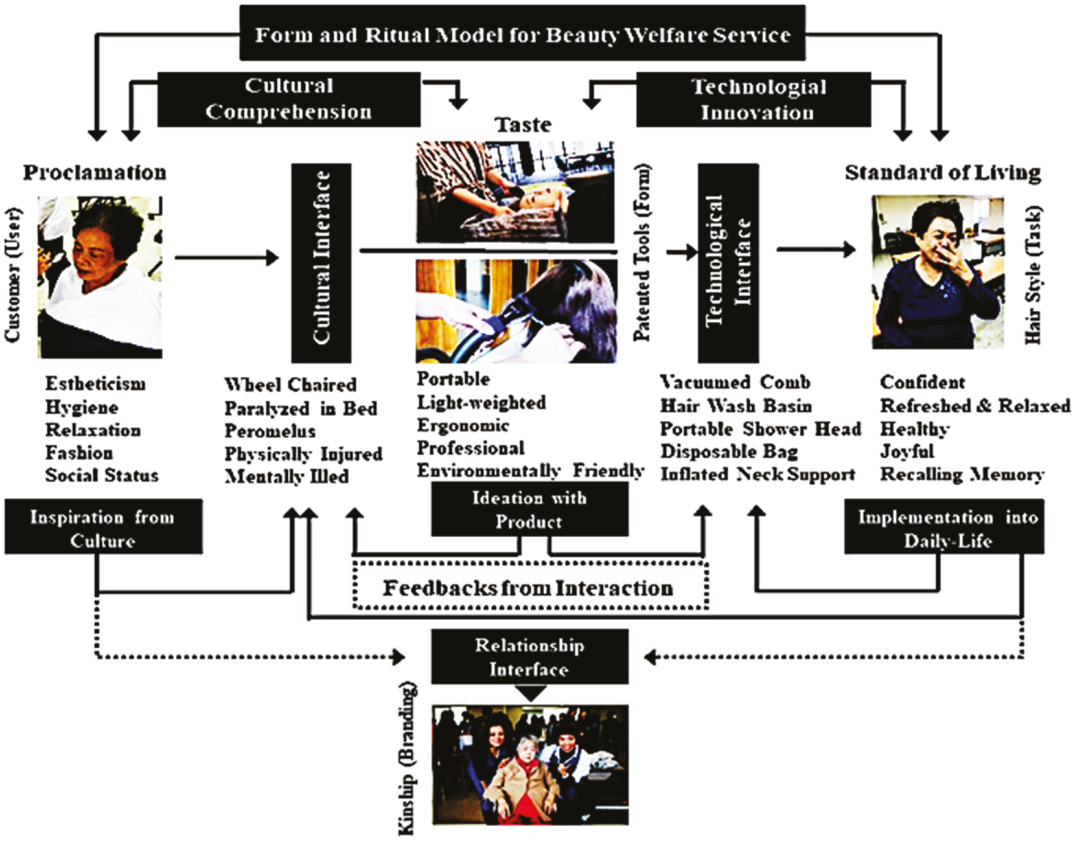

Figure 7. Form and ritual design model for cultural innovation. (Reprinted with permission from [50]. Copy 2019 Lin, C. et al.)

4.3. Participants' Response and Suggestions

Any model and method accumulates experience in practice, improving its details and structure. Although the core theory of the OPOP model is relatively mature, as a relatively new teaching model it still deserves further improvement. The author invited a dozen students who participated in the OPOP forum to conduct research (see Appendix B). They were mainly from GSCID, NTUA. Due to the limited number of participants, the following survey results are for reference only:

- Except for one student who had been exposed to a model similar to OPOP before, the other students, such as the author, were all exposed to the OPOP model for the first time. Everyone gave good comments on the OPOP model. They thought they could obtain a lot of inspiration from it and integrated such research methods into subsequent creation and research; they were also willing to introduce and share the OPOP model with others.
- Many participants believe that it is necessary to further promote the OPOP model by such means as strengthening exchanges with other colleges and departments, holding OPOP forums in other schools, and extending this model to the teaching of universities and master's classes. In addition, several students mentioned that they hoped to make

the conversion process of "From Product to Paper" more concrete and, at the same time, increase the part of "post verification".

5. Conclusions

Since 2018, the OPOP model has become an integral part of the GSCID's curriculum system. Up to now, more than 30 doctoral and master's students have carried out various researches based on the concept of the OPOP model. Therefore, we believe that the OPOP model is relatively successful and feasible. On the one hand, its core theory has been verified many times and a series of structures and systems have been formed which could be flexibly adjusted according to different research topics. On the other hand, OPOP itself is an open model which allows us freedom in the process of applying it.

For readers who were exposed to OPOP for the first time, it is recommended to randomly select 1-2 articles from Appendix C for reading. At the same time, you can ask yourself, if you were to conduct the same type of research, would you also take a similar approach? In other words, could you obtain inspiration from the OPOP model? This was also the learning method the author took when he first came into contact with the OPOP model. It should be pointed out that there are many research methods and models in any professional field. Therefore, the author hopes that readers can use "critical thinking" to examine the OPOP model.

Regarding the future development of the OPOP model, as the participants stated, it is necessary to expand contacts, such as with teachers and students from other schools, and even professional designers, so that more people can understand, use, and think about the OPOP model. Although the articles participating in the OPOP forum were all officially published in different symposiums or journals, the author believes that under the premise of not violating academic ethics, these articles can be considered as a collection of essays and provided to interested readers.

We hope to construct a "general rule" through the OPOP model, but leave as much space as possible for researchers to develop themselves. The motivation of the OPOP model and the research process are based on the accumulation of "individual" one by one, and gradually move towards "general". It is true that any model needs to be continuously improved in the process. Therefore, we will extend this model to different departments and schools (focusing on the fields of art, design, performance, crafts, etc.), and continue to verify this model through feedback from students and scholars.

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Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The author also invited the founders of the OPOP model and asked them to answer four questions in the form of an interview. They participated in all three forums throughout the process, and they were also the instructors of all articles published in the forums. The four subjective questions in the interview are shown in Table A1.

Table A1. The content of the interview.

Introduction
Dear Instructor: The OPOP Forum has been successfully held three times, and it has become a challenge faced by GSCID freshmen after enrollment. To a certain extent, it allows freshmen to quickly enter the research state after enrollment. More importantly, this forum is a platform for everyone to exchange and learn from each other. The author once had the honor to participate in a forum named OPOP. It was also the first time the author came into contact with the OPOP model and learned a lot from it. I am currently writing a paper discussing the application of the OPOP model in design and creative teaching, hoping to comprehensively and objectively evaluate and think about the OPOP model, and share this model with more people. As the creator, organizer, and instructor of the OPOP model, your motivation for creating OPOP and your experience in the process of guiding students will be an important reference for the author when studying the ins and outs and connotation of the OPOP model. It would be a great favor if you would spend 10 min to answer this interview. The answers will be used solely for academic purposes and individual information will be kept strictly confidential. Thank you for your generous participation and cooperation! Sincerely, Yikang Sun 17 April 2021
Questions
1. What was your motivation and rationale for constructing the OPOP model? 2. What do you think is the difference between the OPOP model and other teaching and research models in the field of design and creativity? What are the advantages of the OPOP model? 3. Based on the results of the three forums that were held, what do you think we should pay attention to when we use the OPOP model? 4. Based on the results of the three forums that were held, what do you think can be adjusted for the OPOP model?

Appendix B

The author invited a dozen students who participated in OPOP forums, and asked them to answer related questions in the form of questionnaires. These students come from the Graduate School of Creative Industry Design, National Taiwan University of Arts (GSCID, NTUA). The content of the questionnaire is shown in Table A2.

Table A2. The content of the questionnaire.

Introduction
Dear friends of GSCID, NTUA: The OPOP forum is a big event of GSCID, NTUA. It is a platform for everyone to learn from each other, and it is our common memory! The author is writing a paper related to the OPOP model. The author hopes to evaluate and think about the OPOP model in a more comprehensive and objective manner, and to share this model with more people to participate in the grand event. It would be a great favor if you would spend 10 min to answer this questionnaire. The answers will be used solely for academic purposes and individual information will be kept strictly confidential. Thank you for your generous participation and cooperation! Sincerely, Yikang Sun 17 April 2021
Basic Information
1. Gender □Male □Female
2. Background □Art □Design □Architecture □Crafts □Pedagogic □Performance □Other
3. How many times have you participated in an OPOP forum? □1 □2 □3

Table A2. *Cont.*

Questions
1. Have you been exposed to the same or similar models as OPOP in the past? □Yes (identical) □Yes (analogous) □No
2. Do you think you can adjust to the OPOP model? □Yes □No □Uncertain
3. Can the OPOP model inspire you? □Yes □No □Uncertain
4. Are you in agreement with the OPOP model? □Yes □No □Uncertain
5. Will you apply what you have learned in the OPOP model to your everyday creative and research activities? □Yes □No □Uncertain
6. Will you introduce the OPOP model to others? □Yes □No □Uncertain
7. Do you think there are other parts of the OPOP model that are worth adjusting or improving?

Appendix C

Since 2018, the OPOP forum has been successfully held three times, and the 4th forum is expected to be held in the second half of 2021. The articles used in the first three forums are shown in Table A3. The content of these articles already surpassed design in the traditional sense, covering a wide range, including product design, visual design, craft design, ceramic design, interior design, painting, clothing, interaction, installation art, social welfare, etc. This greatly extends the connotation of the first "P". These articles were further revised and improved, and most of them were accepted by international seminars such as the Human–Computer Interaction International Conference (HCI), or published in journals.

Table A3. List of articles used in OPOP forum, 2018–2020.

Title of Articles	Author(s)
Research on the audience's cognition and preference of the styles of Chinese landscape paintings	Wu, J.; Wu, J.D.; Lin, P.H.
Research on the application of innovation and inheritance based on regional culture: A case study of the innovative design of Atayal knitting box in Taiwan	Gao, Y.J.
A study model on the transformation of "artwork" to "interior design": Take the series of "poetic artwork" series as an example	Gao, Y.J.
Research on the influence of interactivity on the aesthetic cognition of art	Gao, Y.; Wang, I.T.; Lin, P.H.; Lin, R.
Designing gardenia-inspired cultural products	Kuo, S.L.
Assessment of the sense of joy in public artwork in living environment	Lo, H.F.
Analysis of cover design styles of magazines: Taking The Short Story Magazine (1910-1932) as an example	Huang, J.P.; Chen, S.; Wu, J.D.; Lin, R.
A case study of applying 'Black Humor' to ceramic art performance	Hsu, M.L.; Fang, W.T.; Lin, P.H.; Lin, R.
A dialed between nature and man-made and beyond	Wang, I.T.; Lo, H.F.; Gao, Y.

Table A3. *Cont.*

Title of Articles	Author(s)
Study on the aesthetic characteristics of Chinese Chan tea: Cultural elementsand innovative thinking of tea and Chan	Wen, X.
Research on the marketing strategy of green design products: Taking "AURO" and "Even" brand products as examples	Wen, W.I.
Research on creation architecture of opera cartoons	Wu, J.D.; Huang, J.P.; Lin, R.
Comparative analysis of the transition process from painting and calligraphy to ceramics	Yang, C.H.
Museum and cultural products co-creation brand value: Taking the innovative cultural products of Ningbo Port Museum as an example	Chang, C.W.
A feasibility study on the transformation and sustainable development of "Disposable Tableware" in Taiwan night market	Sun, Y.; Lin. S.Y.
A study of Japan's beauty welfare service from cultural innovative perspective	Lin, C.L.; Chen, C.L.
Traditional board game revitalization: A Case study of Bas-basan Sepur	Armayuda, E.
A study on application of enclothed cognition in apparel design	Lin, S.Y.
The pilot study of the theater of the Bauhaus	Ting, Y.W.
Visual data storytelling: A case study of turning big data into Chinese painting	Lyu, Y.R.
Research on the utilization of unconventional materials in fashion styling	Cheng, T.F.
Museum immersion interactive design: Taking the children art gallery exhibition as an example	Chang, C.W.
Application of auspicious cultural in metalworking jewelry design	Shi, M.H.
Research on the application of family elements in environmental education exhibition	Yang, C.H.
A case study of applying 'Black Humor' to ceramic art performance	Hsu, M.L.
A study of applying Bauhaus design idea into the reproduction of the Triadic Ballet	Ting, Y.W.
The co-creation of value between product development and customer experience: Taking "Silkah" as an example	Huang, M.L.
Discussing how the viewer, the author, and the work see and be seen in the photography works of Farewell to the Island	Cheng, H.C.
Transforming the local cultural resources into design: A case study of the Hengshan region placemaking	Chiang, I.Y.
Exploring the integration of emotion and technology to create product value: using QisDesign lighting as example	Chen, J.F.
The unorthodox use of bamboo in fashion styling design	Cheng, T.F.

Table A3. *Cont.*

Title of Articles	Author(s)
Sightseeing illustration map design and effectiveness research: A case study of Hong Kong sightseeing illustration map	Wu, H.C.
Redesign, transformation and reflection of local marriage custom articles: A case study of "the Red Dowry"	Cao, J.
Audience's cognitive research on "incomplete" technique in sculpture art	Tao, Y.H.
Discussion on Zen mind design of products	Huang, T.F.
The interweaving of memory and recollection: A case study of memorial house "Qiyun Residence"	Sun, Y.; Lin, R.

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education sciences

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Article

From Theory to Practice: An Adaptive Development of Design Education

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Abstract: This study aims to discuss the adaptive challenge, and bridge the gap between theory and practice in design education. From now on, navigating design communities through the new era is a significant issue facing global competition and pluralistic society. First, this study reviews the essential evolution of design theories in the past few decades on man-machine system design, user-centered design, and user experience design. Second, based on three case studies of the REACH toothbrushes, an IEF wearable computer, and a LINNAK twin-cup, the research findings are offered to witness the advancement and transformation from hi-tech to hi-touch. Furthermore, this study summarizes three paradigms to interpret the adaptive evolution in design education. Finally, the authors propose three directions for the advancement of the creative industry and design education. The contributions of this study are to (1) clarify the interrelations between the theory and practice of design via the three foci of the human factors, human actors, and cultural aspects; (2) demonstrate the transformation of the archetypal model of user–tool–task employing illustrative paradigms; (3) identify the evolution of design education with contextual stages in the past decades; and (4) propose orientated perspectives for the personnel and institutes of the design industry and design education.

Keywords: design theory; design practice; design education; adaptive development; cultural ergonomics

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1. Introduction

Humans have always striven for a better life. Our ancestors created diverse tools, craftworks, objects, and products via the application of advanced technology of the time to face their challenges in the world. After the industrial revolution, intentions of chasing economic growth caused the blooming of mass production and machine manufacture. Later, for achieving the balance between aesthetic necessity and industrial production, the idea and action of integrating technology and arts and crafts turned into design theories and design practices in the sphere of education and industry. In other words, design education was triggered in the early 20th century because of the enlightenment from the Bauhaus school [1,2]. Across the Atlantic, the concept and implementation of design and design education spread to the United States, then carried forward and brought greater development to the world. Today a century later, as we face global competition and a pluralistic society, navigating design communities through the new era has become a significant issue.

Although humans have been pursuing advanced technology for a better life over long periods, we have perceived that the more high tech humans have, the more high touch humans want [3]. The association, balance, and interface between technology and humanity has become a well-known issue of design since Nokia addressed the concept of "human technology" and "connecting people" in the late 1990s [4–6]. People choose

products according to the benefits they obtain from both hedonic and utilitarian aspects. However, experiential enjoyment is more difficult to evaluate and quantify than practical functionality [7].

This study takes the approach of "from theory to practice" to explore the development of design education from an adaptive perspective. First, this study reviews the essential evolution of design theories on the man-machine system, user-centered, and user experience; second, the authors discuss three empirical cases of design practice as contrast with the corresponding literature review. These research findings witness the advancement from hi-tech to hi-touch and the transformation from human-computer interaction (HCI) to human-culture interaction (HCuI); and address that touch is associated with the symbolic meaning which is always beyond the technology once the functionality has been met. This article has limitations in including the wide-range, comprehensive, and chronicled literature review in design pedagogy. In this article, most discussions and presentations apply to college school, an advanced degree, or in-service design education; and focus on the interfaces and interrelations between artifact creations/products and human cognitions from ergonomic design to cultural product design. This study aims to discuss the adaptive challenge and bridge the gap between theory and practice in design education. The purposes of this study are to (1) clarify the interrelations between the theory and practice of design via the three foci of human factors, human actors, and cultural aspects; (2) demonstrate the transformation of the archetypal model of user–tool–task employing illustrative paradigms; (3) identify the evolution of design education with contextual stages in the past decades; and (4) propose orientated perspectives for the personnel and institutes of the design industry and design education. Finally, the authors hope that these study results will be of practical use and valuable reference for the creative industry and design education.

2. Literature Review on Design Education and Design Theory

2.1. The Challenge and Direction of Design Education

When people discuss the goals and development of design education, one of the efficient ways is to keep exploring the trends and requirements of practical design and innovative entrepreneurial as an essential consultation. As Schaefer et al. (2019) indicated in *Design Education Today* (2019), "good design is human-centered, commercially viable and technologically sound [8] (p. 5)." The experience of good design always delivers a desirable sensation and is inspirational. The design has a significant impact on individuals, societies, and cultures, and shapes the world around us. It is a technical discipline and art that facilitates people to realize their aspirations [8]. Therefore, design practice's challenges, principles, and ideals also become valuable references and guidelines for design education.

Meanwhile, the world faces new challenges; as Meyer et al. (2020) mentioned, "designers are entrusted with increasingly complex and impactful challenges [9] (p. 13)". The capability of designers, design students, and design teachers to develop creative solutions to complex issues is becoming increasingly important. Design is a complicated field; it often needs sophisticated cooperation with cross domains. How design education keeps up with the new demands of the 21st century will be a significant and profound inquiry. According to Ken Friedman's suggestions, Meyer and Norman extended the eleven design challenges in 2020. They divided these design challenges into four groups of performance, systemic, contextual, and global to define the future of design and design education [9]. They also indicated there are two very different types of educational institutions that teach design. A research university concentrates on research activities, theory development, scholarly work and increases general knowledge. Nevertheless, in stand-alone schools of design, the faculty and students emphasize practice. Some gaps indeed exist between the two different educational design institutions, and so too between design theory and practice.

In the context of globalization, Lysenko et al. (2020) addressed the essential factors of modern higher education in quality and competitiveness, "they depend not only on technical achievements, inventions, and knowledge creation but also on organiza-

tional changes [10] (p. 13).” Jardim (2021) mentioned that “cognitive and technical skills are not sufficient to face the professional challenges of the current digital and global world [11] (p. 1)”. They also pointed out the new generations’ challenges in innovative entrepreneurial education.

The strategies through the efficient and stable symbiotic interface achieving the evolution of symbiosis, are a new direction for educational improvement. Wang and Yu (2019) discussed the value of collaborative innovation, which significantly promoted industry and university cooperation. There are many good cases of university collaborative innovation, and they argued that “the synergy between ordinary universities creates much bigger value than the total value that each individual university can provide [12] (p. 12)”. Ruoslahti (2020), based on the European Union (EU) case study of promoting collaboration to explain the value of co-create knowledge, indicated that “complexity characterizes the co-creation of knowledge in innovation projects in various ways [13] (p. 228)”.

When creative education is surrounding the concern of human-centered designs, Metallo et al. (2021) also suggested that “the psychoanalysis of individuals’ unconscious representations, such as deeper fantasies, wishes, and desires, allow us to understand behaviors including the dreams and ambitions of entrepreneurs in the organizations [14] (p. 40)”. In addition, Ali (2019) was concerned with how personality traits affected innovativeness among individuals and satisfaction with life perceptions and proposed an approach to studying an important gap in the body of knowledge. The core values of personality traits, individual innovativeness, and satisfaction with life, are worth in-depth study in design education [15]. The points of the concept are discussed shortly in subsequent research. Lin et al. (2021) pointed out the value of design thinking and situation in design education, “in the past, the primary concern of design education was about designers’ competency rather than the power of design. Design thinking has become increasingly popular over the years because it is proven to be the right approach for the success of design problem-solving and daily activities [16] (p. 7)”. According to the root cause analysis (RCA) report, Cross (2011) summarized the nature of the design. It indicated that design research should focus on the design process, which achieves the task via understanding design cognition and the way of knowing and thinking [17].

When realizing the increasing complexities of design issues, this study tries to illuminate the appropriate approach and find the potential direction for design education. Learning from experiences is one of the essential principles of experiential learning in pedagogy [18]. However, learning to educate from experience is one of the concerns of this study [19]; how does the theory and practice in design education make the balance in harmony. In other words, the cognition and understanding of the interrelation between the design theory and design practice can be the significant guidelines of design education. This study tries to retrospect the archetypal model in the design educating experience. It takes the user–tool–task paradigm as an example to explore its adaptive transformation in the design process to pursue sustainability. In the following paragraphs, the authors review the essential theories of ergonomic design on man-machine system design, user-centered design, and user experience design to highlight the evolution and challenges of three foci on the human factors, human actors, and cultural aspects in the changing design education.

2.2. Man-Machine System Design: Human Factors

In the early days of the 20th century, machine systems were built. The initial human factors concern was the development of principles of machine guarding to ensure worker safety. This was followed by time-motion studies to improve worker productivity. The Second World War with its introduction of high-performance airplanes and machinery necessitated the study of their designs so as not to exceed the human capabilities of their operators. This led to man-machine design with its emphasis on mathematical modeling of the human operator as a “manual controller” component in such systems. These all pertained to military and industrial environments confronting the human. The automobile industry began application of anthropometry for increasing safety and comfort

of drivers. In the early 1970s, concern arose for "consumer product design": the application, modification and extension of human factors principles developed in military and industrial contexts to the design of everyday products for the ordinary human so that they would be satisfying to the consumer and profitable to the manufacturer. The development of the first commercial computer systems in the 1950s and their introduction as consumer products in the 1960s launched research into the user interface [20]. When the "mouse" was invented by Douglas Engelbart in 1968, it fostered the next innovative waves of graphical user interface (GUI) in the 1970s and 1980s.

Those innovations allowed information to be manipulated in a more flexible and friendly way [21]. Norman proposed the direct manipulation interface, which has been well-received by users, as a good form of interface design. He identified two basic phenomena that led to the feeling of directness: one deals with the distance of information processing between the user's intentions and machine's facilities, another phenomenon relates to the relation of interface languages between the input and output; he also mentioned that distance and engagement are the two major aspects with landmark values, especially when the system provides the representation of objects as if they are the objects themselves [22]. Direct manipulation provides the feeling of directness and friendliness, just as WYSIWYG what you see is what you get (WYSIWYG) became one of the important principles of product design [23,24].

The man-machine system also known as human engineering or ergonomics in product design, particularly explores the categories of "human factors", based on the study and analysis of engineering psychology on the mental and physical capabilities and limitations of people to solve complex problems. Kreifeldt (1974) [25] proposed the analysis paradigm of the user–tool–task system as shown in Figure 1 for later discussion with exemplified case studies. This model presented the interactions and adaptive feedbacks, and in particular emphasized the three objects of design: user (human), tool (product), task (goal); the two interfaces: manipulation (user–tool) interface and engagement (tool–task) interface in the human system design [26–28]. Human factors are the major concerns of the manipulation interface, while mechanical engineering tends to be the essential feature of the engagement interface. This prototype model outlined the interrelations and influences between the user–tool, tool–task, and user–task. In other words, the user solves the problem and completes a task via the tool control which usually involves and employs two interfaces of manipulation and engagement. In the following, the user–tool–task model was reproduced and transformed into a more comprehensive system for the application of product design.

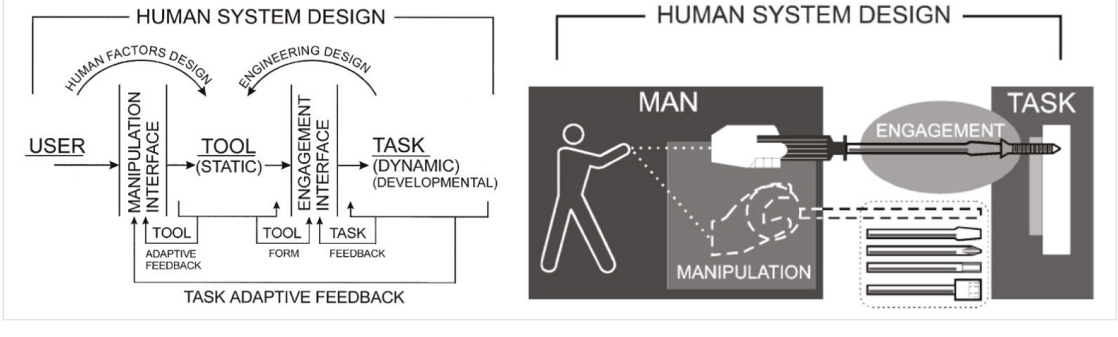

Figure 1. A symbolic framework of user–tool–task paradigm (**left**) and an analogic representation of the user–tool–task system (**right**). (adapted from [28]).

2.3. User-Centered Design: Human Actors

As a distinct species, human beings have two special characteristics. One is the ability to modify the living environment through artifact creation. The other is the corresponding ability to transmit the modifications to the next generations through human language which codifies the precept and procedure [29]. The invention of artificial devices enhances our speed, power, and intelligence. Tool making and usage also define our characteristics as human beings. Many artifacts make us stronger, faster, and smarter, increasing cognitive capabilities [30]. Artifactual tools are generally regarded as extensions of human physical agility. Nevertheless, the psychic situations effect the cognition and operation of such artifactual products. Consequently, the research of user-centered design (UCD) was inspired by the concept of the concerns for human nature and user needs [31].

In 1986, Norman not only proposed the new perspectives on human-computer interaction (HCI) but also engaged in cognitive engineering and tried to apply cognitive science to the design and construction of machines. In addition to computers, many complex devices are difficult to use because of fundamental difficulties in understanding their operation. He addressed some application problems and discussed a few issues which focus on the way that people interact with machines. He also proposed a conceptual prototype of mental models which comprise design model, user's model and system image as providing predictive and explanatory power for understanding the interaction [31]. Designers can communicate with the eventual users only through the system image of a product. Thus, a good designer will make sure that the system image of the final design conveys the proper user model. Norman aimed to facilitate bridging the gap between the gulf of execution (from goals to system state) and the gulf of evaluation (from system state to goals) which provided an orientation for issues of user-centered system design, and moving the user and system closer to each other [22,31,32].

It has become increasingly clear that the interaction between people and task affects the artifact and its usability and performance. When the artifact is combined with the informational and processing structure of human and task, the expansion of cognitive capabilities of the total system of human, artifact (tool, product), and task become an enhanced issue [30]. Designers sought to understand the underlying principles behind human action and performance, and devise systems that were pleasant and fun to use. For achieving "pleasurable engagement", researchers sought new ways of understanding the relationships and constraints between people, technology, and environment. The design communities stressed the research interests of user-centered design and departed from "human factors" to "human actors". At the same time, a larger role was given to the users who are not simply passive objects but active and centered agents within the design process [33].

2.4. User Experience Design: Cultural Aspects

Norman (1985) discussed that when user experiences directly interact with the objects, direct engagement occurs synchronously [22]. In order to deepen its understanding in the core value of user-centered design, Norman proposed the advanced concept of user experience (UX) design. As he suggested in "emotional design" (2004), each of the three processing levels of brain mechanism: Visceral, Behavioral, and Reflective, properly plays a different role in the functioning of human attributes [34]. The visceral level starts affective processing via making fast judgments and sending signals to the muscles and warning the rest of the brain. The behavioral level is more often referred to the practical and functional aspects of usability. The reflective level is the highest level which represents conscious thought and extracts the information to allow people to react intellectually and rationally [35]. Norman's three levels of design all combine to form the entire user experience.

User experience is a major concept in HCI dealing with "a person's perceptions and responses that result from the use or anticipated use of a product, system or service." The perceptions and responses in particular include the user's emotions, beliefs, preferences, accomplishments, physical and psychological responses that occur before, during, and

after use [36–38]. In other words, research of user experience concerns the user's feelings when using a product. User experience can be anything from sad to happy, from hate to love, from apathetic to passion, and so on [36]. Norman also explains the factors and states what affects the user's feelings. People cannot escape from affecting, positive or negative affection changes the way of thinking. Positive affection makes brain learning effective and arouses curiosity and creativity: someone who is in a pleasant mood is more creative. As he stressed, if the product is enjoyable and fun, designers and users will certainly benefit [34].

Those feelings that occur before, during, and after use influence the user's experience; however, the cultural factors rooted in environment, society, community, belief, religion, custom and so forth subliminally affect the user's emotion and cognition. Bruner's overview in *Studies in Cognitive Growth* (1966) stated that "man is seen to grow by the process of internalizing the ways of acting, imagining, and symbolizing that 'exist' in his culture, ways that amplify his powers. He then develops these powers in a fashion that reflects the uses to which he puts [them]" [39] (pp. 320–321). However, Cole and Griffin pointed out in their article "Cultural Amplifiers Reconsidered" (1980), that the different notions that artifacts enhance or amplify may be natural [30,40]. Nevertheless, despite the intertwining and dissension about the process of amplification, some cultures push or affect cognitive growth, and the varieties of cognition change a user's experience consciously or subconsciously.

As Kaplan (2004) mentioned, ergonomics is a continuously evolving field; Helander predicted the extension of cultural ergonomics in the 2000s. Since ergonomics adds cultural to human factors, cultural ergonomics emerged as a new sub-discipline [41]. Immediately, those cultural factors are incorporated into the design considerations. Moalosi et al. (2010) discussed an experimental design approach which was conducted at the University of Botswana, and proposed a model to integrate socio-cultural factors in the design process [42]. The research of Kreifeldt et al. focused on the aboriginal weaving box's appearance, cultural meaning, operational interface, and tried to create a new interface for examining the way of design and culture in the design process [43]. Kolus et al. (2018) proposed empirical evidence to remind that the decisions that impact design go beyond a conventional health and safety perspective [44].

3. Case Study on Design Practice

This study reviews the essential concepts of man-machine system design, user-centered design, and user experience design; also examines the development of adaptive design from "human factors" to "human actors" then "cultural aspects". Following, the authors adapted the user–tool–task paradigm (Figure 1) as an analysis framework for discussing three practical design cases corresponding to the empirical approach from theory to practice. Based on the discussion in adaptive development of an archetypal model of user–tool–task, this study chose three case studies across the 1970s to the 21st century, demonstrating its long-term applicability and transformation.

3.1. Case A: REACH Toothbrush

Toothbrushes are one of the most common and familiar products used in daily life since early childhood. A 17th century Chinese literature once mentioned tools for cleaning the teeth. In 1780, the British William Addis fixed the mane of a hog to an animal bone and created the first toothbrush. In 1857, the first American-designed toothbrush was patented in the United States, and to this day, there are hundreds of patents for manual or electric toothbrushes in design, appearance, function, or operation. Another important milestone in modern toothbrush design occurred in 1938 at the DuPont manufacturing company in Massachusetts, USA, when the first nylon fiber replaced the hog-mane bristle, greatly increasing the production of toothbrushes [45].

The design team of Percy Hill and John G. Kreifeldt of Tufts University is one of the best examples of integrating human factors with design. They accepted a design commission from DuPont in 1971 to develop a statistically supportable improved "teeth cleaning

device" which would be better than those of the competitors. They used scientific research methods and advanced production technology to solve the problem when brushing teeth of reaching the most difficult areas to brush inside the mouth. This project successfully conveys the core values of toothbrush design and demonstrates the coaction for engineering and design principles for which it was awarded the 1976 IDEA Award for excellence of design. As shown in Figure 2, the REACH toothbrush design, which changed the design of toothbrushes, is a successful design in line with human factors principles and is also a well-known and a typical example of man-machine system design and human engineering applied to product design. The technology was then transferred to Johnson & Johnson for mass manufacturing [2,45].

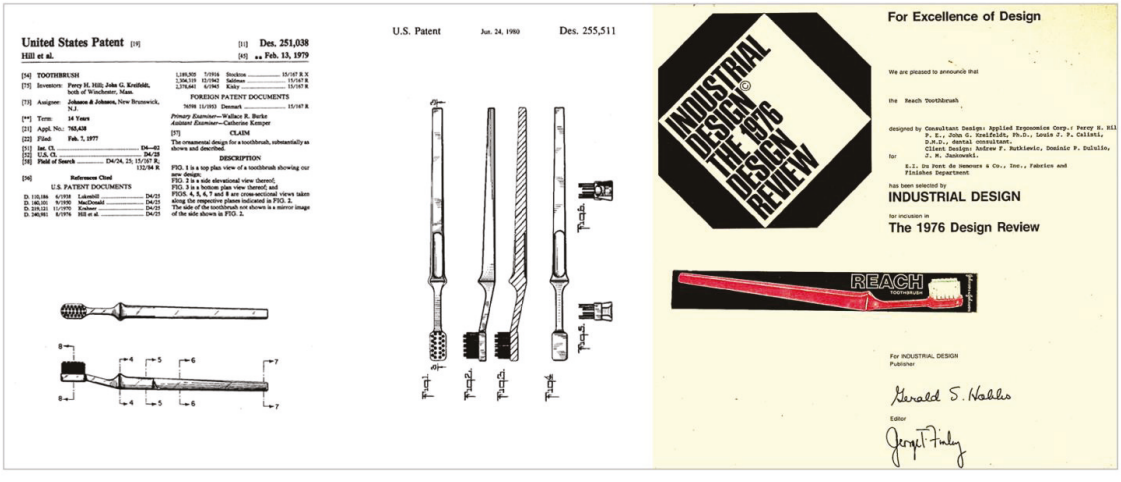

Figure 2. Design draft of REACH toothbrush prototypes (**left**) and the certification of INDUSTRIAL DESIGN for excellence of design in the 1976 design review (**right**) (adapted from [45]).

The design team of the REACH project, in conjunction with the analysis framework of the user–tool–task paradigm formulated by Kreifeldt, was used to conduct a series of studies on the details of people's brushing actions. After time-motion research and human factors analysis, the design team obtained many results about the interrelationship between brushing methods, toothbrushes, and hands [45,46]. This study also applied the user–tool–task paradigm to discuss and realize the final toothbrush design, explain the interaction and feedback among three objects of user (various people), tool (toothbrush), task (dental cleaning) and illustrated the processing factors which exist in the manipulation interface (comfort, operability, safety, user-friendly, etc.) and the engagement interface (brush shape, handle curve, neck angle, material, sensation, etc.) as shown in Figure 3.

The toothbrushes of the REACH series have been popular in the market for nearly 50 years. Today, in order to respond to the concerns and demands of sustainability, REACH also produces the eco-friendly toothbrush with a bamboo body (Figure 3f) [47]. This example explains how product design conveys the core values of the product and humanity through human engineering thinking to affect consumers. This design case of the REACH toothbrush not only shows the perfect combination of man-machine system design and human nature, but also carries out the consequences of "from function to feeling", which is an important strategy to achieve impressive product design and ensure successful marketing in order to return a substantial profit to the manufacturer.

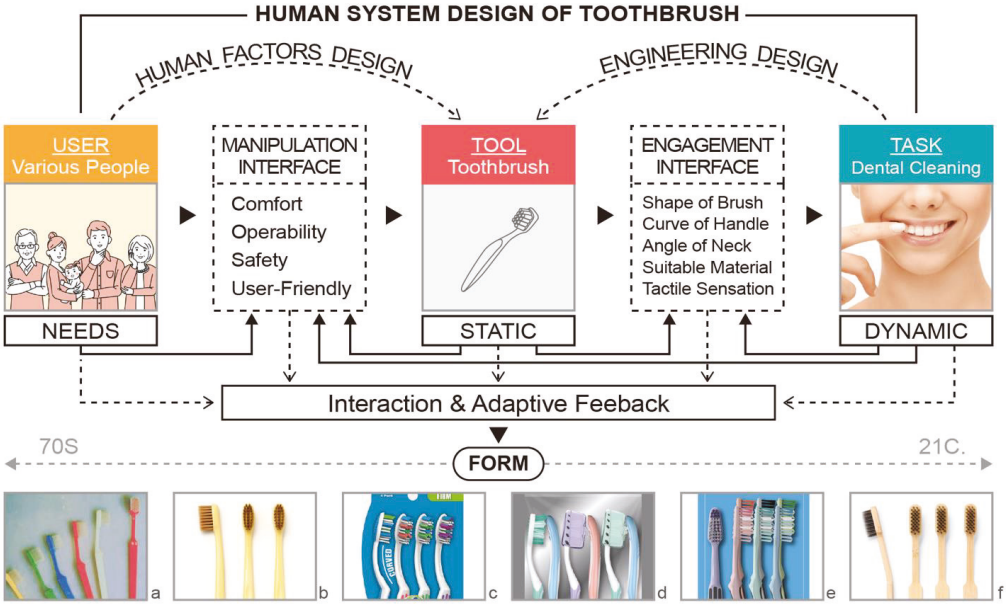

Figure 3. The analysis framework of user–tool–task paradigm as a toothbrush design (adapted from [26]. Bottom image (**a**): adapted from [45], (**b**–**f**): retrieved from [47]. Redrawn for this study).

3.2. Case B: IEF Wearable Computer

This case treats a wearable computer: designing the computer as an Intimate Electronic Friend (IEF) based on the concept of user-centered design in order to explore the human factors and user interfaces of high-technology products design. The case was proposed in 2001, so the following discussions are based on the technological, humanistic, and social contexts of the time [2]. At that time, wearable computers were being developed by many companies because of the rapid advances in technologies [28]. Unfortunately, many consumer products were not suitable for wearing, being either uncomfortable or bulky, causing annoying interference or unexpected disturbance with normal activities. As a result, most of the products rarely reached acceptable performance.

Many wearable attributes which effect the system appropriately belong to the research category of human factors. Therefore, the IEF design team, led by Rungtai Lin the ex-president of the Taiwan Design Center, not only analyzed the correlation and usability between the interfaces and accessories worn by people (Figure 4–left), but also proposed eight checking questions for the referential criteria of wearable computer design [28]. The IEF consists of three objects: helmet mounted display, right upper arm processor, and left forearm input device (Figure 4–right). All three devices are designed to be flexible and suitable for users with various body shapes, and can be worn in different situations comfortably. The main purpose of this case is to show how the designers combined the concepts of human engineering with design thinking under the contextual concepts of technology and design at that time [2,28].

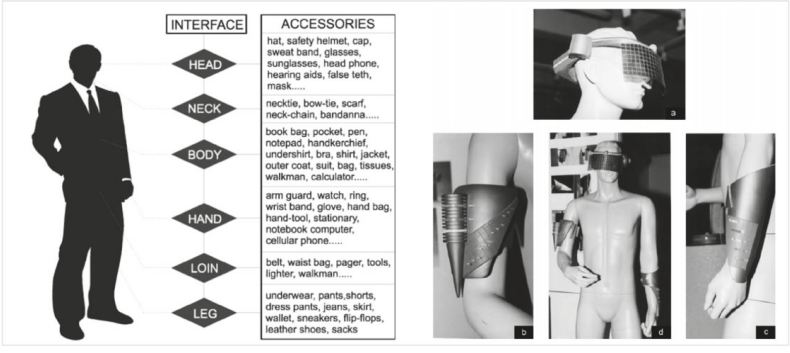

Figure 4. Wearable analysis for human (**left**) and prototype design of the Intimate Electronic Friend (IEF) (**right**) (adapted from [28]).

In order to define the design issues, guide development, evaluate usability, and finalize the wearable computer design, this design case applied the user–tool–task paradigm to analyze human factors in the manipulation interface and explore the engineering matters in the engagement interface as shown in Figure 5. Based on the concept and pursuit of "user-centered design", this practical case of wearable computer design not only focuses on the analysis of human factors, but also stresses the implementation of human actors that concern the user's participation as well as anticipation.

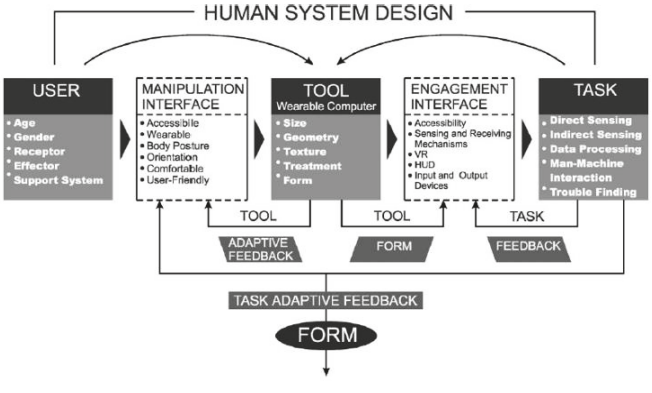

Figure 5. The analysis framework of the user–tool–task paradigm as a wearable computer design (adapted from [28]).

Today, in the world of high-tech ubiquity, we find that high-tech products are becoming smaller and lighter, but they contain more and more fuzzy features and are becoming more and more confusing to consumers. Therefore, how to use ergonomics to fill the gap between the user and the product should be the designer's durative focus [28]. This design case applied the user–tool–task paradigm to achieve the objectives of adaptive product design. This model describes the objects, interfaces, and interactions in the system and aims at fulfilling the wants of humanity as well exploring products that conform to the human nature of human engineering. It can serve as both an organized conceptual framework for user-centered design and a guide to the design process.

3.3. Case C: Linnak Twin-Cup

Aboriginal arts and crafts are always full of energy and passion. In particular a fund of cultural treasures offers great potential for transforming creativity, enhancing design value

and becoming recognized globally [48]. This design case chose the Linnak, an aboriginal "twin-cup" object of the Paiwan tribe in south Taiwan, as a meaningful culture carrier and focused on analyzing its art appearance, cultural meaning, operational interface, and use scenarios. After studies, the usage behavior and meaning of the Linnak was identified as "sharing with each other" [49]. According to three cultural levels [50], the Linnak design team finally accomplished three cross-cultural product designs (Figure 6) to correspond with the design features in each culture layers (outer, mid, and inner).

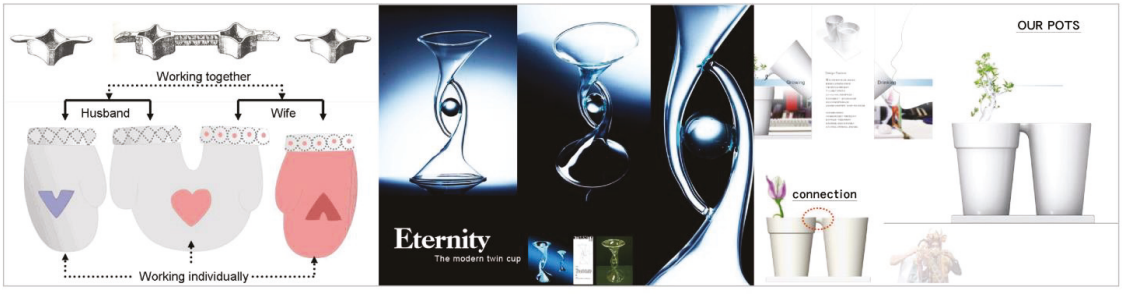

Figure 6. Our glovers: design from the outer level of the Linnak (**left**); our cups for lovers: design from the mid level of the Linnak (**middle**); our pots: design from the inner level of the Linnak (**right**) (adapted from [48]).

The design team of the Linnak project, led by Rungtai Lin, extracted cultural elements of the Linnak and transformed design attributes into modern products that meet the needs of the current market. Designers noted the significance of enhancing product value by associating products with local culture features [48]. The set of "our glovers" (Figure 6–left) extracts the cultural element from the outer level of the Linnak and transfers the meaning to "working together". It was designed for couples to express their relationship. The work of "our cups for lovers" (Figure 6–middle) is a pair of symmetrical cups joined inversely to show the intimate relationship of the drinkers as lovers, its cultural element and behavioral feature are extracted from the mid level of the Linnak. Another design is "our pots" (Figure 6–right). It connects two small pots with each other for cultivating and watering plants together. The spiritual concept of respect and harmony between humans and nature at the inner level is inspired and extracted from the symbolic patterns on the Linnak.

Cultural product design is an acculturation process of reviewing, rethinking, redefining, and redesigning [51]. The strategy of "from denotation to connotation" as used in these three cases for cultural product design emphasizes the analysis and application of "cultural aspects". As discussed in the literature review, cultural affection may amplify the user experience [39,40]. This study adapts the framework that combines the user–tool–task paradigm proposed by Kreifeldt (1974) [25] with the spatially classified cultural scaffold suggested by Leong and Clark (2003) [50] and the three levels of design posited by Norman (2004) [34], to explain the complex interactions and interfaces among human factors, human actors, and cultural aspects as shown in Figure 7 [48–50,52].

This study adds a cultural dimension (interface) to the analysis and discussion of ergonomics for exploring the interaction and experience in product design. Besides the participation in cultural contexts, cultural ergonomics is an important approach that helps designers to extend a better understanding of cultural meaning in the design process and exert the ability to utilize such understanding for designing and evaluating products, and greatly developing interactive experiences for users [52].

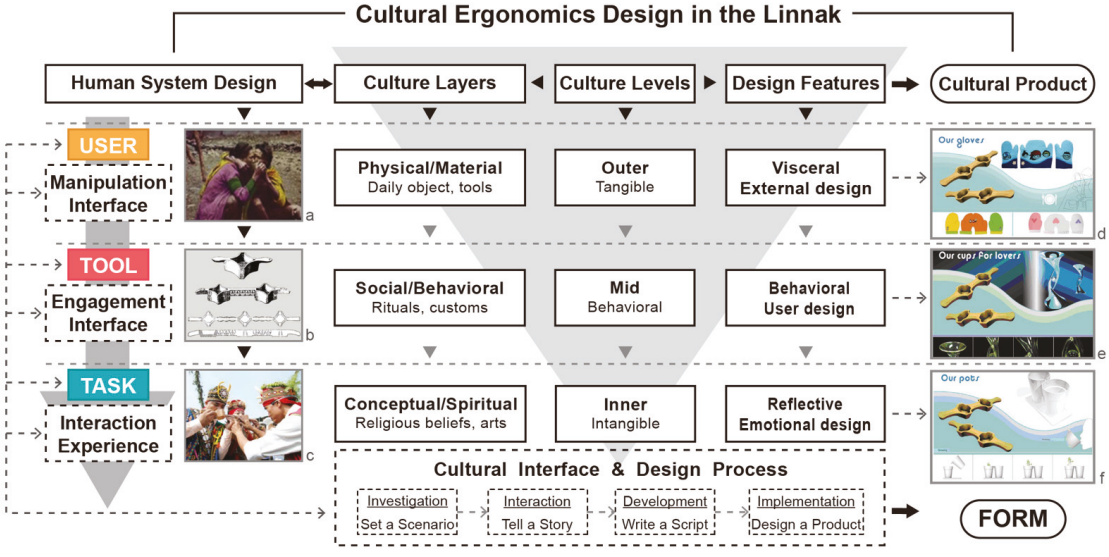

Figure 7. The analysis framework of the user–tool–task paradigm as transforming cultural features into product design (adapted from [48,52–54]. Redrawn for this study).

4. Discussion

4.1. Interrelations of Design Education between Theory and Practice

By reexamining man-machine system design, user-centered design, and user experience design, this study intends to clarify the interrelation of shifting between design theory and empirical practice from human factor, human actor, toward cultural aspect as shown in Figure 8. This approach consists of three stages: (1) At the first stage, design theory is focused on the discussion of man-machine system design about the Human Factors that affects the practical needs of quality design. This study selected the design case of the REACH toothbrush as an example to validate the analysis system of the user–tool–task paradigm. (2) At the second stage, user-centered design is the major topic with the concern for human actors that affects the symbolic wants of adaptive design. This study chose the IEF wearable computer as a design case to inquire further into the established system of the user–tool–task paradigm. (3) At the third stage, based on the vital concept of user experience design, this study explores the culture aspects that touch the aesthetic desires of qualia design in subjective conscious experience. The authors elected the Linnak twin-cup as a meaningful case study to demonstrate the integration of the typical system of user–tool–task paradigm into the spatially classified cultural scaffold and three levels of design as a new perspective of cultural ergonomics.

This study argues that the advancements from quality design to adaptive design and qualia design requires a hybrid of theory and practice which can work harmoniously without dilution of each but may successfully accomplish and strengthen each other when working toward a sustainable future. In fact, the more earnestly cooperation is blended when applying theory and practice towards the ends of design, the more likely it is that the product will have a tractive stimulation for future design paradigms.

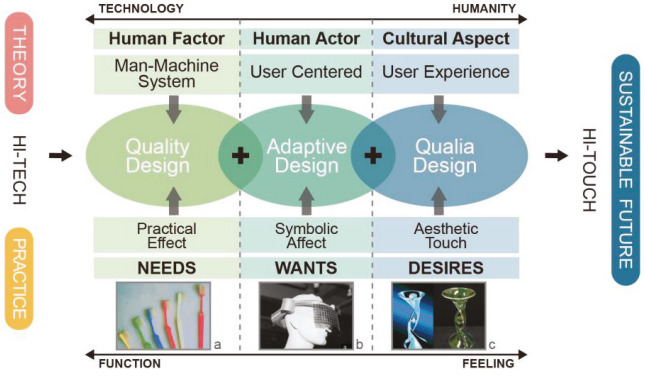

Figure 8. Interrelation and evolution of design education between theory and practice.

4.2. Transfromation of the Archetyhpal Model

One of the purposes of this study is intended to extract the timeless features and adaptive transformation of archetypal paradigms in the interaction between the discussion of design theory and design practice. The authors take the user–tool–task paradigm for example (Figure 9) to illustrate the sustainability of an archetypal paradigm in design process.

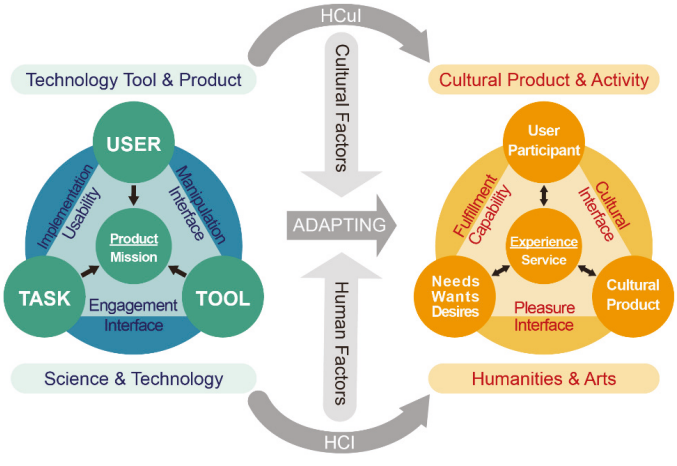

Figure 9. Adaptive development of the archetypal design paradigm (adapted from [55]. Redrawn for this study).

In 2009, Lin et al. [49] (p. 49) stated that "over the past several decades, we have made many efforts to understand human-computer interaction (HCI). But beyond HCI, we need a better understanding of human-culture interaction not just for taking part in the cultural context, but also for developing the interactive experience of users." In contrast with the fulfillment of user experience, the new perspective looks beyond the implementation of product usability. This study transfers the three objects of user–tool–task to user/participant–cultural product–needs/wants/desires, transforms the manipulation interface to the cultural interface, and transforms the engagement interface to the pleasure interface. In order to achieve the adaptation of the development of the design paradigm from HCI human-computer interaction (HCI) to human-culture interaction (HCuI), this study also inspects the necessary changing and shifting from sciences and technology to humanities and arts, and from technology tool and product to cultural product and activity.

4.3. Design Evolution and Contextual Stages

Another intention of this study is to summarize the contextual stages and mega trends of design evolution over the past decades from the active interaction and motivational feedback between design theory and design practice as discussed earlier. In summary, the evolutions consist of three orientations as shown in Figure 10: (1) from function to feeling, (2) from use to user, (3) from hi-tech to hi-touch.

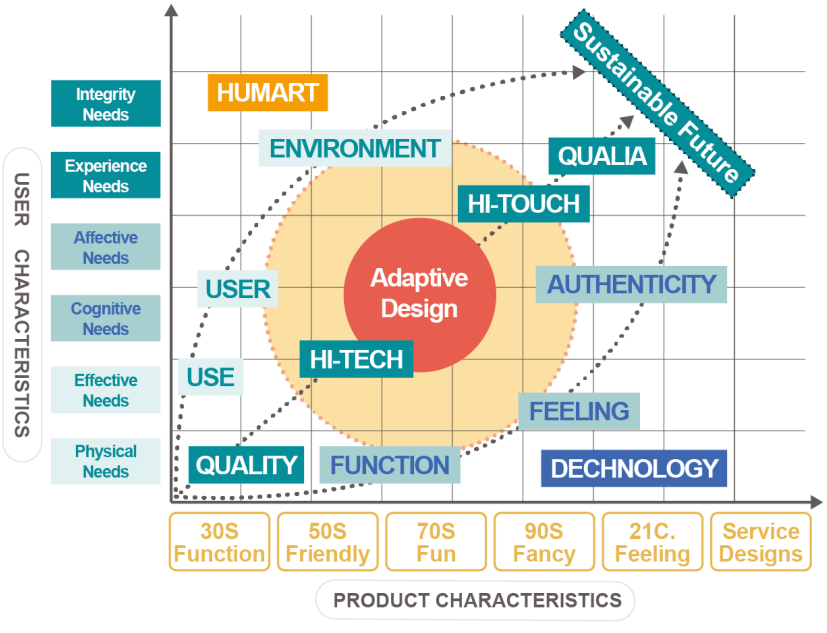

Figure 10. Design evolution with contextual stages (adapted from [56]. Redrawn for this study).

(1) From function to feeling: "Form follows function" had been the major principle of product design in the early 20th century. Today, "design" delivers a new form as "service" in a new platform because of the progress of technologies. The product characteristics have increased from the designing of function for the user's need to the servicing of feeling for the user's pleasure [56–58]. As a result, the design foci have been moving "from product design to service innovation" for pursing the essential authenticity in sincere experience and genuine esthesia.

(2) From use to user: In satisfying the development of user characteristics on human's needs (physical, effective, cognitive, affective, experience, and integrity), the design subjects have been changing "from use to user" for reaching the balance and harmony between human and environment [56]. Thus, the concept of emotional design that stresses "design for feeling" has become the key factor for innovative products.

(3) From hi-tech to hi-touch: Giddens (1984) [59] proposed the concept of "the form of life" to discuss the influence of globalization. Today, in reviewing the evolution "from Dechnology to Humart" of design features, the authors also perceive the transformation "from Quality to Qualia" of lifestyle [56]. It is suggested that careful consideration of the human, social, and cultural factors in the design will enhance its effectiveness [60]. Furthermore, people may apply the hybrid energy of science and arts as well as the extension of "from hi-tech to hi-touch" when pushing adaptive design toward a sustainable future.

5. Conclusions

This study clarified the interrelations and shifting between design theory and design practice by discussing the three foci of human factors, human actors, and cultural aspects. It explored the transformation of an archetypal mode by means of an illustrative paradigm and identified design evolution with contextual stages in the past few decades. Finally, the authors propose three perspectives and suggestions for future planning and further research for the design communities of industry and education.

5.1. The Merging of Man and Machine

We are encountering the rapid evolution of information and communications technology in which adaptive design transformation will create new values for society and industry. Turning attention to our society and environment, there are many challenges which will need to be resolved as we move into the future. For example, as society ages, people will rely more on machines. Thus, there is an urgent necessity for the cooperation and merging of man and machine in the new era of the 21st century. The successful integration of cultural ergonomics and industrial design will result in pleasurable and functional products which provide a superior experience. Based on the concept of "new human-centered design", we may consider how to create and use the new interactive interfaces between man, new machine, and new society.

5.2. The Trade-Off between Technology and Humanity

Actually, we are just at the turning point of "the fourth industrial era" of scientific breakthroughs. There are many technological areas of fascination for us and there is an urge to turn emerging technologies into reality that will change the way of our current life. Amazingly and excitedly, the new era of "The Society 5.0", a super-smart society, will follow soon. Hybrid fusion of technology and humanity will supply the strong stimulation and innovation in the design progress. Nonetheless, reaching the balance and harmony between technology and humanity will be another important issue. What should design and design education be in the new era of change? This study believes that the design of the new era should truly return to the thinking of "human nature" and the reflection on the process of creation and production. Design education in the new era may return to the combination of Dechnology and Humart, which is a meaningful way to keep improving. Design education in the new era may be retriggered by the cultivation of adaptive design thinking and the capability of mindset construction.

5.3. The Adaptability of Design Education

The new era aims at creating a society where people can resolve complex challenges by employing the innovations of the fourth industrial revolution into future life and industry. As a result, designers are facing increasingly complex and weighty challenges in this coming new era of "The Society 5.0". They will be expected to make all people's lives more comfortable and sustainable. Thus, we should immediately re-examine the education system to teach students and support these young designers so they are ready for these crucial issues and future challenges. Learning multi-disciplines and cross-disciplines remain the strategy for design education in order to respond to social evolution and its impact on the new era. Moreover, design education should be more aware of the importance of how to learn and transform the timeless features of the archetypal paradigm from theory to practice in order to cultivate adaptable designers contributing adaptive designs toward a sustainable future life.

Based on the three case studies of the REACH toothbrushes, IEF wearable computer, and Linnak twin-cup, the research findings witnessed the advancement and transformation from hi-tech to hi-touch. Furthermore, this study illustrates the adaptive application of the archetypal model of user–tool–task from the 1970s to the 21st century. These three case studies across the boundaries of location, time, and category demonstrate the applicability of an adaptive paradigm from the daily necessity of the toothbrush, a wearable computer

of commercial electronic product, to the aboriginal cultural product of the creative industry, which demonstrate the potential applicability to a general context.

In conclusion, the authors indicate the challenges and new directions in three aspects: the merging of man and machine, the trade-off between technology and humanity, and the adaptability of design education for future challenges and further research. Significantly, based on the adaptive concept of "new human-centered design," the following study may consider creating and applying the new interactive interfaces between the new generation, new machine, and the new society.

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Comparison of Four Universities on Both Sides of the Taiwan Strait Regarding the Cognitive Differences in the Transition from STEM to STEAM in Design Education

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Abstract: There have been many studies on the effectiveness of the STEAM model since its integration into design education, but further investigation is needed to determine whether teachers and students truly understand the meaning of STEAM. The aim of this study is to evaluate people's perceptions of the STEAM model in design education. Respondents from four universities on both sides of the Taiwan Strait participated in the study. Following expert evaluation and a number of tests, the revised questionnaire was used to survey the attitudes of respondents. The results indicate the following: (1) Respondents were more familiar with universities in their area and therefore rated them relatively highly. While this is reasonable, it suggests that respondents may lack a global perspective. (2) The proportion of arts courses is generally high, but further analysis is required to determine whether they in fact play a role in connecting to STEM. This study concluded that educators and researchers need to have a deep understanding of the essence and connotations of STEAM. Students must also consider how to acquire the knowledge and skills needed for 21st-century design through STEAM courses. Furthermore, the use of STEAM in design education needs to be continuously evaluated and improved.

Keywords: from STEM to STEAM; design education; cognition; four universities; cross-strait

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1. Introduction

From the Bauhaus to the Ulm School of Design, the principles of modern design have been established to have a lasting impact [1–9]. The philosophy of modern design emphasizes the importance of benefiting people over products, and human-centered design is prevalent in the design of products. Therefore, for "product", "design", and "evaluation", the focus is always on humans. These principles are also followed when evaluating products or designs [10]. Similarly, the above points apply to the development and application of the model of design education [11,12]. To achieve benign and sustainable development, it is important to continuously adjust the design education model to meet the needs of the times. As far as design education is concerned, the goal is to implement the essence of design, and to adjust how design responds to technological development and social change [13–15].

Although the core of design education is still influenced by the Bauhaus [16–18], it is worth considering how design education should develop in the future; moreover, the concept and mode of design education also need to be dynamically adjusted, so that the essence and spirit of design can be fully reflected [19]. Additionally, the revision and improvement of the design education model need to answer questions posed by industry. If there is a disconnect between teaching and the practical application of the knowledge and skills, it is difficult for design schools to train students to achieve the competencies they require as designers [20–23].

Design has changed a significant amount during the 21st century, which means that its educational model also needs to be continuously updated [24,25]. STEAM (science, technology, engineering, arts, and mathematics) was used as the theoretical framework of this study; along with questionnaires and analyses, this framework allowed us to examine the current state of STEAM in design education, as well as to understand the cognitive differences between respondents in terms of the STEAM attributes they valued [26].

Taiwan shares the same cultural background as the Chinese mainland, and its modern design is also influenced by the Bauhaus. Additionally, with the deepening of academic exchanges, Taiwan and the Chinese mainland also learn from each other in the field of design education. Previous research has given us the opportunity to understand the strengths, features, and implications of Taiwan and China's design education [27–31].

This article is part of a series of studies. A previously completed study, which is undergoing peer review, analyzed Taiwanese respondents' perceptions of the use of the STEAM model in design education. Thus, this article will conduct research from another angle, analyzing the different views on the same topic among respondents from four universities on both sides of the Taiwan Strait; additionally, it considers the possible reasons for these differences.

2. Theoretical Framework: A Transition from STEM to STEAM with the Support of Art as a Glue

The introduction and research on the basic concept, scope, and core concepts of STEM (science, technology, engineering, and mathematics) and STEAM have attracted much attention from the academic community, and successive published studies have provided strong theoretical support for this research [32–42]. It is unnecessary to rehearse these studies here; we review them only to provide clarification on a central issue, namely, that art has played a huge role in this transformation. If Bauhaus advocated "a new unity, between art and technology", then STEAM advocated the use of art to further unite the principles and methods of technology and science. The purpose of this research is to provide students, designers, and design educators with a means of creating creative products that are more aligned with the arts and humanities. Art will become a key element connecting the other four dimensions (i.e., S, T, E, and M), which will enhance the artistic and humanistic associations of creative products.

STEM is a broad term used to group together these diverse academic disciplines. This term is typically used to address education policies or curriculum choices. The acronym STEM was suggested by Rita Colwell, Ph.D., a bacteriologist who was the director of the NSF in the 1980s [43]. The framework of STEAM derived from STEM, adding the category of art to the original STEM, emphasizing that future students should develop their humanistic and artistic literacy (Humart = human + art) and interdisciplinary abilities. In short, the STEAM framework integrates art and humanity into "rationality and objectivity" [44], and uses art, culture, and humanity to connect to the rational STEM to form a strategy and mode of thinking (see Figure 1).

In summary, STEM focuses on the technical and methodological aspects, while STEAM is a strategy and concept strongly tied to the formation of an art-centered theoretical framework. Many studies also provide strong evidence [45–49]. Art plays a crucial role in connecting the other four attributes in STE(A)M, and becomes the core of this system. "Art" is a very broad concept, and this study argues that it also has cultural implications [50,51].

As discussed in the above, the STEAM model has been applied to education and training. For example, the formulation and application of STEAM education policies allow STEAM to be quickly promoted in teaching in related fields, and in turn examine the rationality and appropriateness of policies [38,52–54]. A large number of specific application examples, as well as critical thinking on the STEAM model, provide a solid foundation for selecting STEAM as the core theoretical framework in this study [28,55–64].

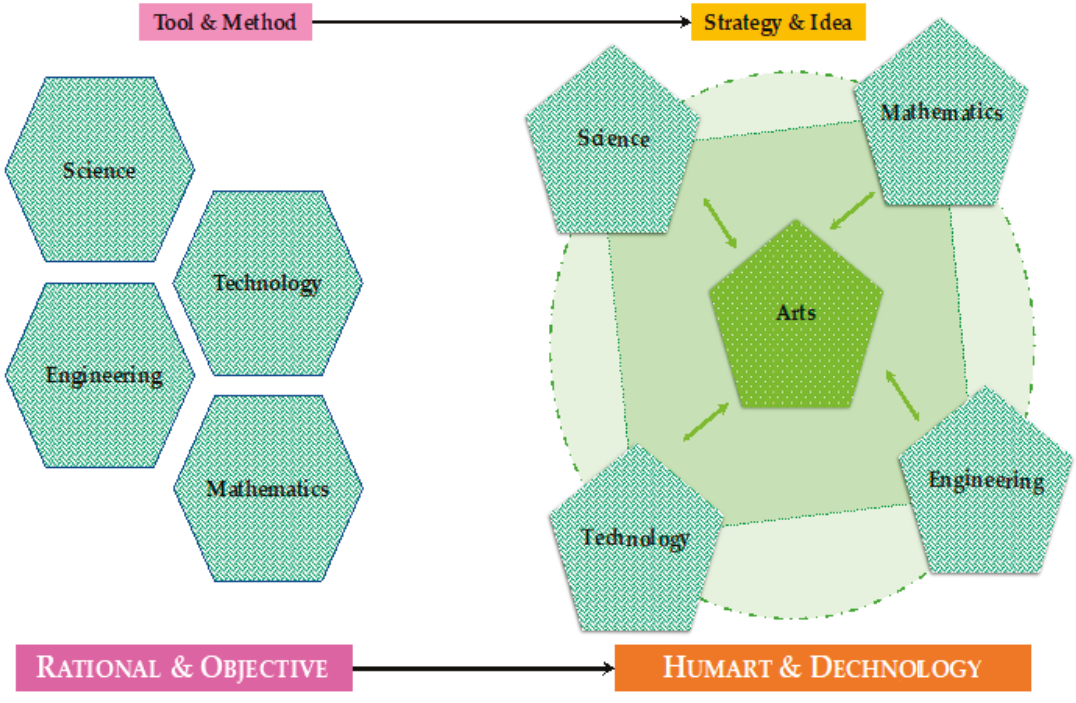

Figure 1. From STEM to STEAM: The fusion of Humart (human + art) and Dechnology (design + technology). (Source: this study).

Another reason for conducting this study as a pilot study is to find out how people differ in their perceptions of STEAM and the relationship between the STEAM model and design education. How is the impact being made? STEAM, which is seen as a new driver, is also essential to ensure that it works as it is intended and can be corrected at any time based on audience feedback [65,66].

3. Materials and Methods

3.1. Hypotheses

Considering that this study aims to examine the application of STEAM in design education, we selected respondents who are either teachers or students at different design schools. Thus, the research hypothesis is focused on the field of design education in universities. Based on the objectives of the study, as well as a literature review, this study proposes the following hypotheses:

Hypothesis 1 (H1). *Respondents who have no study abroad or exchange student experience, may only be familiar with the sample of their country or region, so they will give them a high rating;*

Hypothesis 2 (H2). *Two U.S. universities (RISD and MIT Media Lab) in the sample may be relatively unfamiliar to respondents if they have no experience studying abroad. In this case, the respondents' evaluation will be relatively low;*

Hypothesis 3 (H3). *Respondents from Taiwan are more familiar with STEAM, which leads them to rate the use of STEAM in six universities more highly.*

3.2. Procedures

This study involved the use of a questionnaire analysis to determine respondents' views on the use of STEAM in design education. In order to better focus on the sub-topics to be explored, the data obtained from the questionnaire were analyzed from different perspectives. Therefore, the data collected in the questionnaire were used multiple times, and may be cross-compared in different articles.

The study is divided into three parts (see Figure 2). In part I, a literature review is used to elucidate the difference between STEM and STEAM, and the relationship between STEAM and design education is explored. In part II, experts from the field of design were invited to conduct interviews, and design schools/laboratories from six universities were selected as samples. Once the questionnaire was designed, the researchers invited several experts in the field of design to review the questionnaire and tested it on a small scale. The questionnaire was revised based on comments provided by experts and interviewees. In part III, in addition to descriptive statistics, this study focuses on what is attributed to possible cognitive differences between respondents from four universities on both sides of the Taiwan Strait. Meanwhile, respondents' familiarity with the relevant university is regarded as self-variable, and the differences are analyzed after grouping, to better capture the cognitive differences between different categories of respondents.

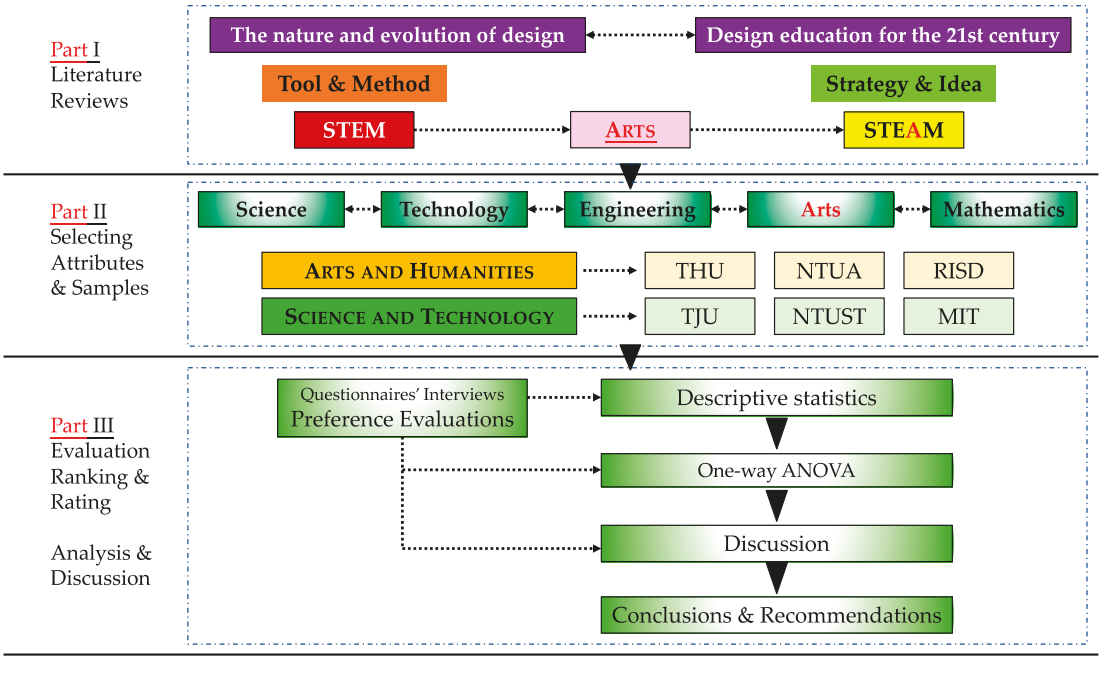

Figure 2. The procedures for deriving the effectiveness of the STEAM model that used in design education. (Source: this study).

3.3. Samples and Their Curriculum

In this study, researchers selected six universities with design colleges or laboratories as samples: (1) the Academy of Art & Design, Tsinghua University, (2) the College of Design and Innovation, Tongji University, (3) the College of Design, National Taiwan University of Arts, (4) the College of Design, National Taiwan University of Science and Technology, (5) the Rhode Island School of Design, and (6) the MIT Media Lab (see Table 1).

Table 1. Samples.

Category	Six Universities with a College or Laboratory of Design
Arts and Humanities	Academy of Art & Design, Tsinghua University (THU) College of Design, National Taiwan University of Arts (NTUA) Rhode Island School of Design (RISD)
Science and Technology	College of Design and Innovation, Tongji University (TJU) College of Design, National Taiwan University of Science and Technology (NTUST) MIT Media Lab (MIT)

Source: this study.

Our selection of these six universities for this study is based on the fact that three of them concentrate on the arts and humanities, and the other three focus on the field of science and technology. This division enables this study to better explore the use of the STEAM model and the current situation of design education in art or technical universities.

Additionally, to ensure the reliability of the sample, focus group interviews (FGIs) made up of several experts in the field of art and design identified the above six universities as a sample. These experts are from the National Taiwan University of Arts. The selection of samples generates a number of challenges. For instance, if the sample is too large, the questionnaire may be too complicated. We use university rankings released by both sides of the Taiwan Strait in recent years as a reference indicator; subsequently, experts identified samples from many universities based on their own experience.

The researchers searched the homepages of design schools at four universities and downloaded their course plans. Although curriculum plans may not be complete (e.g., their homepages do not updated curriculum information in a timely manner), this study believes that these curriculum plans still have reference value. The analysis of these data allows us to understand whether the curriculum planning of design schools in these universities refers to the STEAM model.

3.4. Questionnaire Design and Testing

The questionnaire was divided into two parts: the first part pertained to the respondents' basic information; in the second part, respondents were asked whether they were focused on STEAM at six universities, and then whether the target schools focused on the five dimensions of STEAM. A 5-point Likert scale was used for the responses, with scores ranging from 1 ("Very low") to 5 ("Very high") (see Table 2).

Table 2. The second part of the questionnaire.

Q1: Are you familiar with this university?		Very Low 1 2 3 4 5 Very High
Q2: Please assess whether this university attaches great importance to the use of STEAM in their design education?	**S**cience	Very Low 1 2 3 4 5 Very High
	Technology	Very Low 1 2 3 4 5 Very High
	Engineering	Very Low 1 2 3 4 5 Very High
	Arts	Very Low 1 2 3 4 5 Very High
	Mathematics	Very Low 1 2 3 4 5 Very High

Source: this study.

Regarding the first question, we hoped that respondents could make judgments based on their intuition, so no more explanation was given for this question. During the small-scale test, the respondents did not dispute it.

This article aimed to find out how views on STEAM differ among respondents from four universities on both sides of the Taiwan Strait. Therefore, two versions of the questionnaire were generated. The first version was filled in by respondents from the Taiwan area and the Chinese mainland who are not students or graduates of those four universities. The

second version was available to teachers, students, or graduates from the four universities. We adjusted the options in age and education level to allow those who have not yet graduated from college to answer the questionnaire.

Following pre-testing and revision, the questionnaire was launched on 26 October 2022. Considering that some respondents may not be able to respond immediately, we extended the time for questionnaire collection appropriately. We checked the questionnaires one by one, focusing on whether there were any indiscriminate or incomplete questionnaires. Following checking, all questionnaires were deemed to be valid. SPSS 28.0 was used to further process and analyze the data.

4. Results and Discussion

4.1. Descriptive Statistics

The data related to the respondents are shown in Table 3:

- Respondents from the Taiwan area and the Chinese mainland (none of whom were teachers, students, or graduates of the four universities) used the first version of the questionnaire. A total of 128 respondents from Taiwan and 222 respondents from the Chinese mainland participated;
- Teachers, students, and graduates from four universities used the second version of the questionnaire. There were 115 and 60 respondents from the National Taiwan University of Arts (NTUA) and the National Taiwan University of Science and Technology (NTUST), respectively. There were 35 and 64 respondents from Tsinghua University (THU) in Beijing and Tongji University (TJU) in Shanghai, respectively.

Table 3. All respondents in the experiments.

Variables		Taiwan Area (n = 128)	NTUA (n = 115)	NTUST (n = 60)	Mainland China (n = 222)	THU (n = 35)	TJU (n = 64)
Gender	Female	47/36.7%	79/68.7%	14/23.3%	151/68.02%	9/25.71%	25/39.06%
	Male	81/63.3%	36/31.3%	46/76.7%	71/31.98%	26/74.29%	39/60.94%
Age [1]	18–22	/	29/25.2%	11/18.3%	85/38.29%	13/37.14%	21/32.18%
	23–35	/	18/15.7%	11/18.3%	111/50%	7/20%	34/53.13%
	26–35	18/14.1%	17/14.8%	4/6.7%	/	/	/
	36–45	31/24.2%	31/27%	12/20%	17/7.66%	11/31.43%	7/10.94%
	46–55	52/40.6%	17/14.8%	15/25%	5/2.25%	4/11.43%	/
	56–65	22/17.2%	3/2.6%	7/11.7%	4/1.8%	/	2/3.13%
	>65	5/3.9%	17/14.8%	4/6.7%	/	/	/
Education level	University Student	/	33/28.7%	8/13.3%	77/34.68%	12/34.29%	15/23.44%
	Graduated from University	9/7%	8/7%	18/30%	7/3.15%	4/11.43%	5/7.81%
	Masters	47/36.7%	42/36.5%	25/41.7%	128/57.66%	11/31.43%	39/60.94%
	Ph.D.	72/56.3%	32/27.8%	9/15%	10/4.5%	8/22.86%	5/7.81%
Do you know STEAM?	Yes	98/78.4%	74/64.3%	37/61.7%	119/53.6%	25/71.43%	35/54.69%
	No	27/21.6%	41/35.7%	23/38.3%	103/46.4%	10/28.57%	29/45.31%
Studying abroad? (More than 1 year)	Yes	40/31.3%	26/22.6%	8/13.3%	13/5.86%	9/25.71%	7/10.94%
	No	88/68.8%	89/77.4%	52/86.7%	209/94.14%	26/74.29%	57/89.06%
The country or region where you are studying abroad	United States, Canada	20/15.6%	14/12.2%	3/5%	2/0.9%	3/8.57%	/
	Europe	4/3.1%	6/5.2%	2/3.3%	4/1.8%	3/8.57%	3/4.69%
	Asia	12/9.4%	5/4.3%	2/3.3%	5/2.25%	3/8.57%	3/4.69%
	Australia, New Zealand	3/2.3%	1/0.9%	1/1.7%	/	/	/
	None	88/68.8%	89/77.4%	52/86.7%	209/94.14%	26/74.29%	57/89.06%
	Other	1/0.8%	1/0.9%	1/1.7%	2/0.9%	/	1/1.56%

[1] The age of the respondents varied between versions of the questionnaire. Therefore, regarding the age variable, the options are slightly different.

The familiarity of the respondents of the six universities is shown in Table 4. It is reasonable to assume that the respondents are familiar with universities in their countries or regions. However, even with samples from the respondents' country or region, a certain percentage of the respondents were unfamiliar with part or all of the sample. This may have affected their in-depth evaluation of the sample.

Table 4. The mean and std. deviation of the respondents' familiarity with six universities.

	THU	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Taiwan Area (n = 128)	2.18 (1.111)	2.27 (1.245)	3.95 (1.229)	3.43 (1.215)	2.34 (1.220)	2.91 (1.160)
	NTUA > NTUST > MIT > RISD > TJU > THU					
NTUA (n = 115)	2.10 (1.18)	1.77 (1.035)	3.75 (1.22)	2.83 (1.237)	1.93 (1.19)	2.34 (1.263)
	NTUA > NTUST > MIT > THU > RISD > TJU					
NTUST (n = 60)	1.65 (1.039)	1.58 (1.062)	2.88 (1.474)	3.42 (1.476)	1.87 (1.255)	2.63 (1.507)
	NTUST > NTUA > MIT > RISD > THU > TJU					
	THU	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Mainland China (n = 222)	2.75 (1.120)	2.45 (1.171)	1.93 (1.143)	1.78 (1.075)	1.85 (1.130)	2.01 (1.186)
	THU > TJU > MIT > NTUA > RISD > NTUST					
THU (n = 35)	3.89 (1.105)	2.74 (1.120)	2.00 (1.163)	1.77 (0.942)	2.49 (1.197)	2.51 (1.095)
	THU > TJU > MIT > RISD > NTUA > NTUST					
TJU (n = 64)	3.05 (1.188)	3.02 (1.188)	2.20 (1.311)	1.98 (1.105)	2.05 (1.188)	2.50 (1.321)
	THU > TJU > MIT > NTUA > RISD > NTUST					

Note: samples that are most familiar to the respondents are marked in gray shading.

In the twenty-first century, students can learn about the current situations in renowned universities in other countries or regions by using the internet, and can also use open-source data to study online. However, this may not be sufficient to give students a comprehensive understanding of a university or of a specific department. However, these benefits are still out of reach for students in economically and socially underdeveloped areas. In fact, even in developed countries or regions, there are still many students who are unable to access the educational resources of other countries or regions due to economic constraints (e.g., some families cannot afford to pay for internet communication). Therefore, this study posits that the reasons for the emergence of the above phenomena are more complex than this one explanation allows. However, it is still necessary for students to take advantage of various opportunities and conditions to expand their international perspectives. In recent years, due to the COVID-19 pandemic, international communication has been restricted, but online communication has developed rapidly, and many universities or research institutions have overhauled their homepages and shared numerous resources. This provides great convenience for students, including teachers.

The respondents' assessments of whether these six universities focus on STEAM are shown in Table 5. The responses reflect the following trends:

- Respondents from the four universities may have been objective, rather than simply scoring intuitively. For example, they argued that MIT deserves the highest score in some attributes, which is consistent with the actual situation. This may be related to the prestige of MIT;
- Some of the respondents were not from the four universities mentioned above. However, these people rated the two universities in their home country relatively highly. For example, respondents from the Taiwan area (teachers, students, and graduates who are not from NTUA and NTUST) rated NTUA and NTUST relatively highly. This may be due to the respondent's intuitive reaction. For example, if respondents have not studied abroad or even used the internet to learn about other universities, they may have given relatively high ratings to universities in their country or region out of patriotic feelings. However, the situation reflected in the above assessment may also

be more consistent with the actual situation. Follow-up studies will further analyze whether this phenomenon is real and the reasons for its occurrence.

Table 5. The mean and std. deviation of the respondents' assessment of the STEAM model.

Taiwan Area (n = 128)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.23 (1.233)	3.14 (1.085)	2.88 (0.988)	3.88 (0.944)	3.26 (0.941)	4.44 (0.903)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Technology	3.26 (1.186)	3.23 (1.103)	3.16 (1.007)	4.16 (0.903)	3.34 (0.891)	4.50 (0.939)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Engineering	3.16 (1.200)	3.15 (1.065)	2.58 (1.024)	3.97 (0.922)	3.26 (0.982)	4.38 (0.940)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Arts	3.69 (1.266)	3.51 (1.190)	4.57 (0.928)	3.36 (1.070)	3.88 (1.047)	3.62 (1.080)
	NTUA > RISD > THU > MIT > TJU > NTUST					
Mathematics	2.94 (1.228)	2.99 (1.112)	2.35 (0.977)	3.45 (0.971)	2.97 (0.922)	4.21 (0.993)
	MIT > NTUST > TJU > RISD > THU > NTUA					
NTUA (n = 115)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.27 (1.15)	3.01 (1.158)	2.79 (1.039)	3.65 (0.937)	3.13 (0.996)	4.21 (1.055)
	MIT > NTUST > THU > RISD > TJU > NTUA					
Technology	3.36 (1.069)	3.27 (1.187)	3.20 (1.061)	4.00 (0.927)	3.37 (1.037)	4.26 (1.027)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Engineering	3.22 (1.138)	3.14 (1.139)	2.80 (1.053)	3.77 (0.974)	3.08 (0.890)	4.19 (1.067)
	MIT > NTUST > THU > TJU > RISD > NTUA					
Arts	4.05 (1.083)	3.67 (1.212)	4.56 (0.797)	3.34 (1.075)	3.77 (1.071)	3.37 (1.151)
	NTUA > THU > RISD > TJU > MIT > NTUST					
Mathematics	3.10 (1.116)	3.01 (1.112)	2.42 (1.043)	3.41 (1.016)	3.06 (1.003)	4.10 (1.068)
	MIT > NTUST > THU > RISD > TJU > NTUA					
NTUST (n = 60)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.28 (1.166)	3.20 (1.117)	2.73 (1.071)	4.08 (0.979)	3.17 (0.977)	4.02 (1.066)
	NTUST > MIT > THU > TJU > RISD > NTUA					
Technology	3.53 (1.171)	3.23 (1.079)	3.05 (0.982)	4.20 (1.054)	3.28 (1.043)	4.13 (1.112)
	NTUST > MIT > THU > RISD > TJU > NTUA					
Engineering	3.20 (1.286)	3.23 (1.079)	2.98 (1.157)	4.12 (1.010)	3.35 (1.087)	4.10 (1.130)
	NTUST > MIT > RISD > TJU > THU > NTUA					
Arts	3.60 (1.153)	3.27 (1.133)	4.25 (1.068)	3.98 (1.033)	3.52 (1.112)	3.52 (1.097)
	NTUA > NTUST > THU > MIT > RISD > TJU					
Mathematics	3.13 (1.270)	3.10 (1.040)	2.73 (1.150)	3.73 (1.250)	3.17 (1.080)	3.93 (1.150)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Mainland China (n = 222)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	2.58 (1.355)	2.32 (1.262)	2.02 (1.149)	2.02 (1.218)	1.89 (1.142)	2.32 (1.444)
	THU > MIT = TJU > NTUA = NTUST > RISD					
Technology	2.62 (1.379)	2.38 (1.336)	2.01 (1.165)	2.06 (1.252)	1.93 (1.200)	2.36 (1.485)
	THU > TJU > MIT > NTUST > NTUA > RISD					
Engineering	2.49 (1.338)	2.41 (1.378)	2.00 (1.146)	2.02 (1.224)	1.94 (1.189)	2.31 (1.457)
	THU > TJU > MIT > NTUST > NTUA > RISD					
Arts	3.32 (1.333)	2.81 (1.376)	2.35 (1.379)	2.07 (1.186)	2.28 (1.444)	2.24 (1.339)
	THU > TJU > NTUA > RISD > MIT > NTUST					
Mathematics	2.36 (1.340)	2.22 (1.270)	1.93 (1.113)	1.94 (1.134)	1.84 (1.114)	2.29 (1.471)
	THU > MIT > TJU > NTUST > NTUA > RISD					

Table 5. *Cont.*

THU (n = 35)	THU	TJU	NTUA	NTUST	RISD	MIT
Science	3.17 (1.224)	3.11 (1.255)	2.37 (1.060)	2.69 (1.255)	2.71 (1.274)	3.71 (1.487)
	MIT > THU > TJU > RISD > NTUST > NTUA					
Technology	3.54 (1.291)	3.29 (1.274)	2.34 (0.998)	2.77 (1.308)	2.97 (1.317)	3.91 (1.483)
	MIT > THU > TJU > RISD > NTUST > NTUA					
Engineering	3.37 (1.215)	3.23 (1.308)	2.43 (1.037)	2.51 (1.147)	2.94 (1.282)	3.66 (1.414)
	MIT > THU > TJU > RISD > NTUST > NTUA					
Arts	4.20 (0.933)	3.54 (1.314)	3.20 (1.410)	2.74 (1.245)	3.80 (1.410)	3.40 (1.288)
	THU > RISD > TJU > MIT > NTUA > NTUST					
Mathematics	2.89 (1.132)	2.86 (1.216)	2.23 (0.973)	2.49 (1.197)	2.69 (1.207)	3.57 (1.441)
	MIT > THU > TJU > RISD > NTUST > NTUA					
TJU (n = 64)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.00 (1.272)	2.98 (1.327)	2.47 (1.284)	2.50 (1.392)	2.45 (1.272)	3.08 (1.546)
	MIT > THU > TJU > NTUST > NTUA > RISD					
Technology	3.11 (1.323)	3.12 (1.315)	2.42 (1.270)	2.48 (1.380)	2.56 (1.446)	3.08 (1.515)
	TJU > THU > MIT > RISD > NTUST > NTUA					
Engineering	3.00 (1.297)	2.98 (1.303)	2.53 (1.345)	2.45 (1.308)	2.41 (1.342)	3.03 (1.469)
	MIT > THU > TJU > NTUA > NTUST > RISD					
Arts	3.64 (1.200)	3.44 (1.332)	2.92 (1.473)	2.47 (1.259)	2.89 (1.565)	2.95 (1.506)
	THU > TJU > MIT > NTUA > RISD > NTUST					
Mathematics	2.91 (1.411)	2.72 (1.303)	2.28 (1.175)	2.42 (1.355)	2.36 (1.326)	2.95 (1.527)
	MIT > THU > TJU > NTUST > RISD > NTUA					

Note: samples that receive the highest ratings on different attributes of STEAM are marked in gray shading.

4.2. Differences in Respondents' Perceptions

One-way ANOVA was used to determine whether there was any cognitive difference among the respondents from the four universities, and the results are shown in Table 6. It can be seen that, with the exception of TJU, there were significant differences in the respondents' perceptions of the other five universities with different attributes.

Through in-depth analysis and interpretation of the data, the following characteristics can be found:

- Respondents from NTUA and NTUST rated both the cognitive differences in the attributes that were highly rated;
- The standard deviation of some attribute scores was large, indicating that perceptions of them varied widely between respondents.

4.3. The Sample's Curriculum and Its Relevance to STEAM

This study will further analyze the curricula of these four universities, enabling us understand the real situation of the STEAM model in use in these four universities (see Table 7). The following inferences can be drawn from the curricula of these four universities:

- With the exception of the Department of Architecture at NTUST, art courses have the highest proportion of different departments at these six universities. Typically, the department of architecture or the school of architecture is relatively independent. Although elements of art are also essential to architecture, they may not be prioritized;
- Some departments do not offer courses related to science or mathematics. Few departments retain a certain proportion of technology-related courses because they require technical support;
- Due to the different definitions of course categories in each country or region, and the fact that some courses may be interdisciplinary, there is a certain percentage of courses that cannot be included in any category in STEAM, and can only be temporarily replaced by "Other". The proportion of these courses is not very low.

Table 6. The differences between respondents from four universities.

Sample	Attribute	Source of Variation	*SS*	*df*	*MS*	*F*	Post Hoc Tests
THU	**A**rts	Between Groups Within Groups Total	15.360 332.421 347.781	3 270 273	5.120 1.231	4.158 *	1 > 2; 1 > 4; 3 > 2; 3 > 4
NTUA	**T**echnology	Between Groups Within Groups Total	7.531 332.834 340.365	3 270 273	2.510 1.233	2.037 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
	Arts	Between Groups Within Groups Total	10.122 355.892 366.015	3 270 273	3.374 1.318	2.560 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
NTUST	**S**cience	Between Groups Within Groups Total	104.447 332.213 436.661	3 270 273	34.816 1.230	28.296 ***	2 > 1; 1 > 3; 1 > 4; 2 > 3; 2 > 4
	Technology	Between Groups Within Groups Total	142.449 341.756 484.204	3 270 273	47.483 1.266	37.513 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
	Engineering	Between Groups Within Groups Total	131.618 320.907 452.526	3 270 273	43.873 1.189	36.913 ***	2 > 1; 1 > 3; 1 > 4; 2 > 3; 2 > 4
	Arts	Between Groups Within Groups Total	80.579 347.380 427.960	3 270 273	26.860 1.287	20.877 ***	2 > 1; 1 > 3; 1 > 4; 2 > 3; 2 > 4
	Mathematics	Between Groups Within Groups Total	77.393 373.877 451.270	3 270 273	25.798 1.385	18.630 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
RISD	**S**cience	Between Groups Within Groups Total	24.161 326.379 350.540	3 270 273	8.054 1.209	6.662 ***	1 > 4; 2 > 4
	Technology	Between Groups Within Groups Total	29.150 377.566 406.715	3 270 273	9.717 1.398	6.948 ***	1 > 4; 2 > 4
	Engineering	Between Groups Within Groups Total	30.366 329.269 359.635	3 270 273	10.122 1.220	8.300 ***	1 > 4; 2 > 4; 3 > 4
	Arts	Between Groups Within Groups Total	34.989 425.479 460.467	3 270 273	11.663 1.576	7.401 ***	1 > 4; 2 > 4; 3 > 4
	Mathematics	Between Groups Within Groups Total	27.345 343.184 370.529	3 270 273	9.115 1.271	7.171 ***	1 > 4; 2 > 3; 2 > 4
MIT	**S**cience	Between Groups Within Groups Total	55.207 419.727 474.934	3 270 273	18.402 1.555	11.838 ***	1 > 3; 1 > 4; 2 > 4; 3 > 4
	Technology	Between Groups Within Groups Total	61.438 412.459 473.898	3 270 273	20.479 1.528	13.406 ***	1 > 4; 2 > 4; 3 > 4
	Engineering	Between Groups Within Groups Total	61.263 409.015 470.277	3 270 273	20.421 1.515	13.480 ***	1 > 3; 1 > 4; 2 > 4; 3 > 4
	Mathematics	Between Groups Within Groups Total	57.359 425.112 482.471	3 270 273	19.120 1.574	12.143 ***	1 > 3; 1 > 4; 2 > 4; 3 > 4

Note: * $p < 0.05$, *** $p < 0.001$; respondents from four universities: 1. NTUA, 2. NTUST, 3. THU, 4. TJU.

Table 7. The curriculum of four universities.

NTUA	Science	Technology	Engineering	Arts	Mathematics	Other	Total
			1. Department of Visual Communication Design				
Curriculum	0	16 (20.50%)	4 (5.12%)	32 (41.02%)	0	26 (33.33%)	78
			Arts > Other > Technology > Engineering				
			2. Department of Crafts and Design				
Curriculum	1 (1.02%)	6 (6.12%)	6 (6.12%)	53 (54.08%)	1(1.02%)	31 (31.63%)	98
			Arts > Other > Engineering > Technology > Mathematics > Sciences				
			3. Department of Multimedia and Animation Arts				
Curriculum	0	42 (56.75%)	1 (1.35%)	7 (9.45%)	0	24 (32.43%)	74
			Technology > Other > Arts > Engineering				
			4. Curriculum in General Education				
Curriculum	0	6 (35.29%)	0	6 (35.29%)	0	5 (29.41%)	17
			Science = Arts > Other				
NTUST	**Science**	**Technology**	**Engineering**	**Arts**	**Mathematics**	**Other**	**Total**
			1. Department of Design				
Curriculum	0	23 (28.78%)	8 (10%)	27 (33.75%)	0	22 (27.5%)	80
			Arts > Other > Technology > Engineering				
			2. Department of Architecture				
Curriculum	0	5 (8.77%)	19 (33.33%)	14 (24.56%)	5 (8.77%)	14 (24.56%)	57
			Engineering > Other > Arts > Technology = Mathematics				
THU	**Science**	**Technology**	**Engineering**	**Arts**	**Mathematics**	**Other**	**Total**
			1. Department of Visual Communication				
Curriculum	0	4(7.69%)	1(1.92%)	43 (82.69)	0	4 (7.69%)	52
			Arts > Technology = Other > Engineering				
			2. Department of Environmental Art Design				
Curriculum	2 (3.5%)	1(1.75%)	8(14.03%)	36(63.15%)	1(1.75%)	9(15.78%)	57
			Arts > Other > Engineering > Science > Technology = Mathematics				
			3. Department of Industrial Design				
Curriculum	0	5(9.43%)	3(5.66%)	33(62.26%)	0	12(22.64%)	53
			Arts > Other > Technology > Engineering				
TJU	**Science**	**Technology**	**Engineering**	**Arts**	**Mathematics**	**Other**	**Total**
			1. Department of Media & Communication Design				
Curriculum	0	14(37.84%)	0	14(37.84%)	1(2.7%)	8 (21.62%)	37
			Technology = Arts > Other > Mathematics				
			2. Department of Industrial Design/Product Design				
Curriculum	0	8(21.62%)	6(16.21%)	14(37.83%)	1(2.7%)	8 (21.62%)	37
			Arts > Technology = Other > Engineering > Mathematics				
			3. Department of Environmental Design				
Curriculum	0	8(21.62%)	6(16.21%)	14(37.83%)	1(2.7%)	8 (21.62%)	37
			Arts > Technology = Other > Engineering > Mathematics				

Source: quoted from the official website of these six universities, and collated by the authors.

Many students are not familiar with the curriculum of the relevant college or department when choosing a university, but will be influenced by the university's attributes. When they enter university, it is important to ensure that the curriculum is appropriate.

This study indicates that the curriculum arrangement of the design department largely depends on the orientation of the university to which it belongs. In general, it requires not only highlighting the advantages and characteristics of the university, but also flexibly adapting to the actual circumstances and focusing on a particular direction, such as the field of human–computer interaction (HCI). Consequently, the curriculum planning of the design department should find a balance in the STEAM model. It is also critical to note that these courses cannot be designed simply to incorporate the five dimensions of STEAM.

Moreover, in order to better grasp the objectives of the curriculum, teachers and students must have a deep understanding of the essence and connotations of STEAM.

5. Conclusions and Recommendations

5.1. Conclusions

Based on the results presented in the questionnaire, as well as the sample curriculum planning of the sample, the three hypotheses proposed in this study are deemed to be valid. If the respondents have no experience studying abroad, their knowledge of schools they have never attended is limited, which may lead to assessments that do not match the actual situation. Although the STEAM model has been widely used, there are still differences in its implementation between different countries or regions. For example, since STEM was introduced to universities in mainland China in 2016 and is still in the development stage (STEAM is also not widely practiced in design education in mainland China), participants from universities in the United States, where STEM and STEAM were developed, are encouraged to support the identification of cognitive difference, thus improving the replicability of the results.

Design educators and researchers need to have a deep understanding of the essence and implications of STEAM. Students must also consider how to acquire the knowledge and skills needed for 21st-century design through STEAM courses. For example, in some countries or regions, the STEAM model has just been applied to design education, and teachers and students lack rich experience. It is necessary to continuously collect feedback from these people. So, the use of STEAM in design education needs to be continuously evaluated and improved.

5.2. Limitations and Follow-Up Research

The limitations of this study, which will be further addressed in subsequent studies, include the fact that all of the respondents in this study are from Chinese-speaking areas, and a large proportion of them have no experience studying abroad, so their assessment of STEAM cannot be discussed more widely for the time being. As part of this research series, we will further cross-compare the results obtained from different perspectives. In the future, we will analyze respondents' evaluations of two samples from the USA. If possible, we plan to invite teachers and students from these two universities to answer our questionnaire. Their answers can be compared with our findings.

This study posits that science, technology, engineering, and mathematics can be mastered through systematic, scientific, standardized, and continuous training, but artistic and humanistic literacy requires the long-term accumulation of knowledge. In addition, using art to connect science, technology, engineering, and mathematics can also prompt people to think about the humanistic connotations of the four dimensions of STEM from another perspective.

From STEM to STEAM, it is possible that the concept of "arts" can play a major role in connecting the other four attributes. It is expected that future research will focus on what changes "art" brings when it is connected to the other four attributes (science, technology, engineering, and mathematics) as well as what new inspiration and enlightenment these changes can bring to design education. Researchers and educators in the field of design should pay attention to this issue. Although the current research is still ongoing, we would like to reiterate our call for more people to participate in the exploration of the use of STEAM models in design education.

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From Cultural Heritage Preservation to Art Craft Education: A Study on Taiwan Traditional Lacquerware Art Preservation and Training

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Abstract: In Taiwan, preservation and training policies of intangible cultural assets are highly valued by the government. In this study, lacquerware art craft education as intangible cultural heritage is the subject of this study. We conducted in-depth interviews and secondary data collection to obtain research data and carried out a grounded theory data analysis method through expert meetings to explore the passing on education strategy of "lacquerware art craft" in Taiwan. Firstly, based on Bloom's educational objectives, the study analyzed three aspects of lacquer art education: cognitive, affection and skill, and proposed a "Lacquerware Art Passing-On Education Framework Diagram". Later, the analysis results of the grounded theory enable us to summarize the "Lacquerware art value and learning structure diagram". In this structure, it reveals that the Lacquerware artist's way of thinking about the craft levels can echo the system of the Three Extremes of the Tao in the Book of Changes and divide the value levels of creation into the levels of tools of livelihood, way of living and philosophy of life.

Keywords: intangible cultural heritage; preserving and training project; lacquer art; Taiwan

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1. Foreword

The actual measures of passing on and preserving "cultural heritage" indicates how a nation-state respects ethnological culture and shows its maturity [1,2]. Taiwan's cultural history has several centuries of diversity and cultural memory resulting from different historical contexts of different ruling regimes and eras, and these historical contexts have set the tone of a cultural diversified Taiwan today. In 1995, the Council for Cultural Affairs (CCA) launched "The Plan for the Preservation and Transmission of Folk Arts" to preserve valuable intangible cultural assets in Taiwan. In 2005, with the promulgation of "Cultural Heritage Preservation Law", which clearly defined the mission of preserving traditional arts [3]; the preservation and transmission works were officially involved in general administrative affairs. In 2009, the local government and the central government began to register and designate the custodians of intangible cultural assets and implemented a preservation and transmission plan [4,5].

To understand the current development of Taiwan's intangible cultural assets inheritance and education, this study has explored relevant textual materials in the early stage and found that there are many published books and research reports that record Taiwan's lacquerware art that can clearly explain the historical context of development, record important events and figures, and introduce their works. However, we have discovered that the literature and these materials focus on the basic description of events; there is a lack of records on the promotion of inheritance education and educational concepts. Therefore,

this study chose to discuss the passing-on education strategy of "lacquerware art" with methods such as in-depth interviews, grounded theory, and other research methods. This study explores the cultural value of traditional lacquerware art in Taiwan, the philosophy, methods, and characteristics of lacquerware art education, and the art craft value structure. We intend to analyze the cultural values of traditional lacquerware art in Taiwan, the rationale of lacquerware education, and the methods and characteristics used by lacquerware conservators in education.

2. Development of Taiwan Lacquerware Art and Preservation and Transmission Education

2.1. Taiwan Lacquer Art and History of Origin

The lacquer tree is a deciduous tree that grows in East and South Asia countries, such as China, Japan, South Korea, Vietnam, Myanmar, Thailand, and India. Therefore, lacquerware art culture can be described as a type of art originating in the Asia. The lacquer tree takes eight years to mature, and the lacquer sap is obtained by cutting the bark of the mature lacquer tree at an oblique angle with a sharp blade and allowing the lacquer tree sap to naturally flow out. The lacquer sap is white and turns brownish red after solidification. After a period, it is oxidized and then transforms into a blackish dark brown color. Natural lacquer sap is an environmentally friendly material that beautifies, protects, and could be painted on various surfaces [6–9].

Before 1895, the lacquer tree cultivation technology and techniques for processing lacquer trees were unfamiliar in Taiwan. At that time, lacquer supplies relied on sea imports, so they were less popular and were only used for special occasions such as weddings and funerals to show the significance of the event. From 1895 to 1945, during the period of Japanese rule, the Japanese introduced lacquer trees from Vietnam to Taiwan in 1921. In 1916, the "Yamanaka Crafts Institute" was established, and in 1928, the "Taichung City Craft Education Center" was founded and began to cultivate Taiwanese lacquerware-making talents for lacquerware techniques. This was the earliest practice of lacquer craftsmanship in Taiwan, and Taiwan's lacquerware art culture originates from this time [10].

Taiwan's lacquerware art has only been developing for about a hundred years, a short period compared to China, which has an eight thousand years' history of developing lacquer craftsmanship. However, due to Taiwan's warm and humid climate, it provides a fertile environment for a number of natural materials, such as bamboo, lacquer, wood, etc. The promotion of lacquer tree cultivation and the training of lacquer professionals that began during the Japanese rule period enabled Taiwan to gradually break away from its dependence on lacquer craftsmanship and lacquer imports during the Ming and Qing dynasties, and become able to export its products to Japan and other countries [11].

Taiwanese lacquerware art originated in 1916 when the lacquerware artist Yamanaka (1884–1945) established the "Yamanaka Craft Institute" to start manufacturing and teaching classes and to serve as a base for product sales. In 1928, the Taichung Municipal Government and the Governor-General's Office jointly funded and subsidized the establishment of the "Taichung City Craft Education Center" and officially launched a systematic school, with the goal of passing on knowledge and skills related to craftsmanship. It established a woodworking sector and a paintwork sector and was divided into a two-year undergraduate major and a one-year research department. Ten students were recruited annually, and the center provided them with meals and daily necessities. Two years after graduation, it was stipulated that the graduated students must live in Taichung city, and they were obliged to do the relevant work. In 1936, the Taichung City Craft Education Center was changed into a private operation and was renamed "Private Taichung Craft Education School". In 1937, it was renamed "Private Taichung Polytechnics School" and expanded its enrollment from the original 10 pupils to 30 pupils. Applicants needed to meet the requirements of graduating from a small public school to improve the quality of enrolled students. There were lacquer and furniture subjects in the school, with a three-year period of study, and in that year the school initiated the admissions for "specialized students" with a two-year study period. After the National Government came to Taiwan in 1945, due

to the poor management of the school, the Taiwan People's Association bought the school and transformed it into the "Chien Kuo Craft Vocational School". In 1947, due to political factors, the Education Department of Taiwan Province announced that the school would be disbanded and abolished, ending the development of lacquerware art in the Japanese rule era [5,12].

2.2. The Development of Art Education in Taiwan

The earliest promotion of art education in Taiwan can be traced back to 1897 (Meiji 30) when the Taiwan Government-General's Office proposed a "Specific Plan for the Establishment of Public Schools in Taiwan" to initiate art education programs in Taiwan's education. In 1902 (Meiji 35), the "National Language School" added "Calligraphy and Painting" and began art education in Taiwan. Later, in 1934, the Japanese government established the Committee of Art Education in the Ministry of Education, which led Taiwan to the enlightenment period of art education. After the national government came to Taiwan, although curriculum standards were activated, local teaching materials were rarely included due to the overall political, economic, and social atmosphere. In 1982 and 1984, in accordance with the Implementation Rules for the Cultural Heritage Preservation Law, the Ministry of Education included the curriculum guidelines in local textbooks and began to apply historical, cultural, and artistic values as the editorial guidelines for textbooks. In 1989, the Standards Revision group for middle and primary schools added the "local art" to the standard curriculum, which was an important milestone in cultural education. From 1993 to 1995, the curriculum standards were drastically revised, and "Taiwan's local art textbooks" were included in the curricula of primary and secondary schools, until the local art education gradually entered normalization. In 1998, the Ministry of Education set the curriculum goals of art subjects to "Art and Humanities", which includes traditional opera, music, dance, fine arts, and indigenous art. Taiwan's cultural education tends to be diverse and has built the Taiwanese people's knowledge and recognition of local culture [12].

Due to the close cultural relationship between Taiwan and Japan, after the restoration of Taiwan, the people still used lacquerware, while in Japan, due to the rapid economic development and high labor costs, they began to seek ways to export related lacquerware supplies from Taiwan to Japan. The lacquerware art craftspeople cultivated during the Japanese Rule period, such as Huo-Qing Chen, Qing-Shuang Wang, and Gao-Shan Lai, were successively put into the production of lacquerware to provide the society and export needs at that time. The years between 1976 and 1986 were the heyday of lacquerware in Taiwan. There were many types of lacquerware products, such as wedding supplies, religious celebration supplies, tea trays, household altar tables, jewelry boxes, and flower utensils. At that time, there were about 40 lacquerware production factories. After the 1980s, with the rising labor costs in Taiwan and the forest protection policy, the traditional industries that required heavy manual processing gradually moved out. Since then, the domestic and foreign markets for lacquerware have gradually shrunk [13]

2.3. Policies and Programs for Craft Heritage Education in Taiwan

In recent years, Taiwan's craft inheritance education has been divided into formal school education, skill transfer programs held by the government in accordance with the cultural heritage laws, self-training courses from social groups, or courses handled by individual craftsmen. The development history of the identification and support of important technologies and persons for the preservation of cultural heritage is seen in early law records. Starting from the "Cultural Heritage Preservation Law" in 1982 and the "Implementation Rules on Cultural Heritage Preservation Law" in February 1984, intangible cultural assets such as art, folk customs, and related cultural relics were included in two chapters of the Japanese Cultural Property Protection Law [14]. In 1985, the Ministry of Education held the "Folk Art Heritage Awards" [15]. In 1989, it passed the selection and inheritance of education points of "Important Folk Art Artists", and the first group of national important folk art artists were selected, and the government began to promote

the education of the inheritance of various intangible cultural assets and skills. In 1995, the Council for Cultural Affairs implemented the "The Plan for the Preservation and Transmission of Folk Arts", which implemented four types of programs: preservation, training, research, and others. The training categories were further divided into traditional drama, music, and crafts. The plan was the most comprehensive in the categories, and projects supported by the government at that time. It was promoted in two phases, totaling more than eight years, and more than 2000 students received training reference numbers [16].

In 2005, the "Cultural Heritage Preservation Law" was revised, which merged the fourth chapter, "Folk Art" and the fifth chapter, "Folk Customs and Related Cultural Relics". They have put the old law as the content of the fifth chapter of the newly revised law, "Traditional Art, Folk Customs and Related Cultural Relics". At the same time, a registration and designation system was established to delegate authority and responsibility to local governments. The local governments investigate and register intangible cultural assets in various places, while the central government selects important ones from the traditional arts registered by the local governments for review and designation as "Important Traditional Arts, Important folk Customs and Related Cultural Relics", and they designated the first batch of important traditional art conservators and preservation groups in 2009. The "Cultural Heritage Preservation Law", which was revised and promulgated in July 2016, consolidates various types of traditional arts, folk customs, and related cultural relics into chapter seven "Intangible Cultural Assets" [3], and handles the "The Transmission Project for Important Traditional Arts Preservationists and Preservation Groups" (hereinafter transmission and preservation project) in accordance with Articles 92 and 97 and Article 34 of the "Rules for the Implementation of the Cultural Heritage Preservation Law" [15]. This plan is open for conservators or preservation groups to submit their own implementation plans. The conservators (often called artists or national treasures) will choose three to four art apprentices or recommend potential preservation and transmission artists to the Cultural Heritage Bureau. During the implementation of the plan, the artists must live, work together, and co-create with the conservator. By adopting the inheritance education strategies such as "oral transmission" and "incidental teaching method", it may achieve the learning effect of the mentoring system. In accordance with "The Transmission Project for Important Traditional Arts Preservationists and Preservation Personnel Completion Assessment Principles", the art apprentices participating in the project must finally go through an on-site implementation and demonstration, on-site oral examination, data review, and other parts of the evaluation reviewing the artistic ability, skill content, learning experience, humanistic literacy, knowledge, etc.; the apprentices would have to pass an evaluation that marks the preservation and transmission of the traditional art apprentice.

3. Research Method

Taiwan has been promoting programs and activities related to the inheritance of intangible cultural assets for more than 30 years, and thousands of students have acquired traditional skills as a result. Through the "Transmission Project for Important Traditional Arts Preservationists and Preservation Groups" promoted in recent years and the related data and the project results provided by the Cultural Heritage Bureau, these data have shown that in the year 2020, there have been 68 artists who have completed the workshop, including three artists in lacquerware craftsmanship. To thoroughly analyze how the preservation of lacquerware art craftsmanship carries out inheritance education and sorts out the context of education, this study chose to adopt an in-depth interview method, text data collection, and analysis, etc. The research processes planned in this study is shown in Figure 1. In Figure 1, it is explained that after confirming the purpose of the study, the in-depth interviews and secondary data collection were carried out to collect relevant data, and expert meetings were used to conduct a grounded theory, from which the "Lacquerware Art Passing-On Education Framework Diagram" and "Lacquerware

Art Value and Learning Structure Diagram" were proposed, and finally, conclusions and suggestions were made.

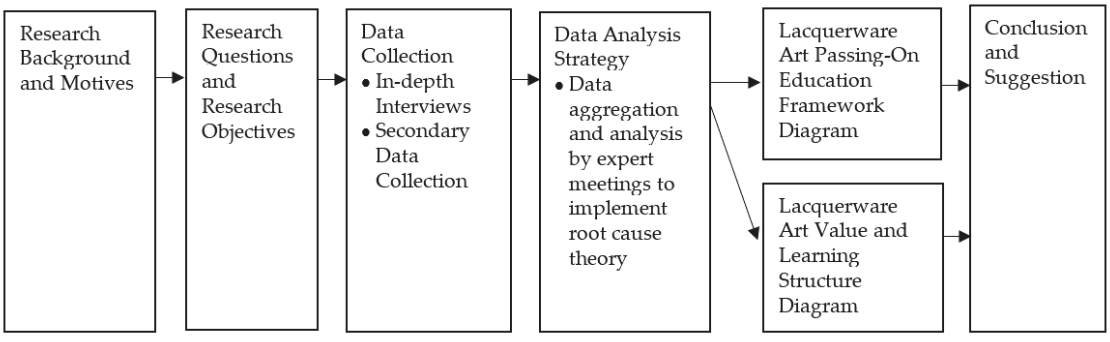

Figure 1. Research Processes.

3.1. In-Depth Interview

3.1.1. Interviewees

In this study, a total of nine experts, including two central government-recognized lacquerware craft cultural heritage conservators, one lacquerware craft and one cultural heritage conservator (recognized by Nantou County government), one graduate artist participating in the transmission and preservation project, four artists engaged in lacquerware art craft, and two public sector personnel who promoted the preservation and transmission project, were interviewed. The interview period was between November 2020 and March 2021. Table 1 is the Respondent's Information of this research.

Table 1. Respondent's Information.

Respondent	Years of Experience	Age	Gender
Preserver of cultural heritage of lacquer art designated by the Ministry of Culture	77 years	100 years old	Male
Preserver of cultural heritage of lacquer art designated by the Ministry of Culture	66 years	85 years old	Male
The transmission and preservation project graduated art student	47 years	71 years old	Male
Lacquer artist	25 years	59 years old	Male
Lacquer artist	28 years	57 years old	Male
Lacquer artist	25 years	57 years old	Female
Lacquer artist	5 years	27 years old	Male
Cultural Assets Bureau/Deputy Secretary	27 years	59 years old	Male
Cultural Assets Bureau, Heritage and Folklore Section/Chief	17 years	48 years old	Male
National Taiwan Craft Research and Development Institute/Lacquer Art Researcher	15 years	44 years old	Female

3.1.2. Theoretical Basis of Interview Content

The 12-year national basic education policy implemented in Taiwan has emphasized the core value that addresses the "core competency" thinking, which includes three major educational goals, which are knowledge, cognition, and skills. Additionally, the policy emphasizes three performance orientations that learning results should possess. The three performance orientations were developed by Bloom, Krathwohl, and Simpson et al., who divided teaching goals into three fields: cognitive, affective, and sensory [17–21]. With the abovementioned theoretical basis, the interview outline of this study was divided correspondently in three aspects (cognition, affection, and skills) to analyze the ideology of educators, learners, and policy agents on lacquerware art education strategies.

3.2. Text Data Collection

In addition of collecting first-hand data through in-depth interviews, this research also collected relevant research, lacquer art-related books, the preservation and transmission plan implementation rules, policy basis, achievement reports, and journals; these data were collected for reference and supporting evidence during inductive analyzation.

3.3. Inductive Analysis Strategy

The analysis strategy of this study was divided into two parts. First of all, for the education strategy of lacquer art, it was based on the three types of educational objectives (cognitive field, affective, and skill) as proposed by Bloom et al.; and we proposed the "Educational Framework for the Transmission of Lacquer Arts". The second part was conducted in grounded theory with in-depth interviews and a verbatim manuscript, and textual data were jointly encoded and analyzed. The grounded theory was carried out in three stages: open coding, axial coding, and selective coding. The grounded theory methodology used in this study was not chosen to be conducted via software, but rather through expert meetings. The main concern during the interviewing processes were whether the artists expressed their ideas in an metaphorical and abstract way. In order to avoid misunderstandings of the meaning of sentences by using software, the data analysis process of this study was conducted by three coding scholars who carefully discussed various data in conference. The three scholars, with backgrounds in cultural heritage preservation research, cultural education, educational policy, and educational evaluation, discussed the data and proposed a "Lacquerware Art Value and Learning Structure", and discussed the characteristics of lacquer art in this framework.

4. Data Analysis

4.1. Lacquerware Art Education Strategy

This study was based on the educational goals of cognition, affection, and skills as the analytical structure. From the in-depth interviews and textual data, three coding scholars firstly proposed the "Lacquerware Art Passing-On Education Framework Diagram", as shown in Figure 2 below.

This framework shows the comprehensive structure of the education of lacquerware art craft. In terms of cognition, the interviewees emphasized that learners should have an understanding of art history and the appearance and trends of the art market in modern society. Such knowledge is conducive to the confirmation of the future creation and development position of art apprentices. In other words, during the learning process, art apprentices should start thinking about and defining their own position in the art market to think about the direction of their possible future development. This cognitive mindset could benefit the art apprentice by confirming future creation and the development of art career. Regarding the knowledge of lacquer art technology, the artists should be able to understand and master lacquer-related knowledge, processes, tools, and pigment characteristics.

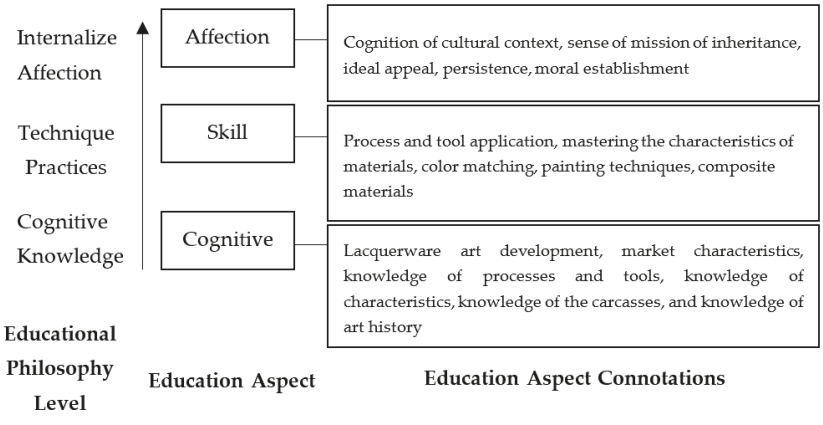

Figure 2. Lacquerware Art Passing-On Edu.

This framework shows the complete framework of education in lacquer art education. The knowledge of lacquer art should be understood and mastered in terms of lacquer-related knowledge, process, tools, and characteristics. As Taiwan's lacquer art heritage conservator Master Wang Qing-Shuang said, "Lacquer art can be used as the decorator of all kind of art craft, and it can be expressed on almost any material, such as ceramics, bamboo weaving, wood carving, and metalworking, so learners must learn various art types in a diversified way". For example, one of the interviewees, an artist who has been working in lacquer art for more than 30 years, specializes in the creation of ceramic-carcassed lacquerware. He chooses to use biscuit fired pottery as the medium for his lacquer art creation, and even experiments with a combination of glaze and lacquer materials, and shows the unexpected color expression under different temperatures! In other words, from the cognitive point of view, learners must master the properties of various materials, and through guidance and experience, they can gradually master the presentation of color.

In terms of skills, the transfer plan requires the art apprentices to study closely with the conservator during the period of transmission and preservation project and gradually master various lacquer techniques in their daily creation and work processes, especially the mastery of basic processes, tools, the characteristics and applications of composite materials, painting techniques, and style mastery. During the four-year period, although the transfer plan was conducted in the mode of "oral transmission and teaching" and "incidental teaching method", it started from the cultivation of basic aesthetics, such as sketching, observation, deconstruction, and color mastery; only then did it gradually enter a higher level of techniques, as well as the final stage of creation, innovative operation, and discourses. Master Wang Xian-Min, a Nantou County registered lacquer art cultural heritage conservator, said, "although there are only two important steps in the creation of lacquer art, one is basing and the other is decorative painting, it is extremely time-consuming and it is common that each piece takes 1–2 years to complete, which is an essential process to cultivate an artist's heart. As for the cultivation of aesthetic sense, we must start from sketching and drawing, and learn from nature by observing the colors of nature!" As for the techniques of lacquer art, they will be taught by means of apprenticeship, learning from imitation and copying. For example, an interviewed art apprentice who participated in the Transmission and Preservation project said: "We will first learn to draw peonies, which represent wealth and prosperity, or peacocks, which represent good luck and kindness, from our tutors. Though this has market considerations, it is essential to have these basic skills training in order to understand the application of color materials and the mastery of techniques".

In terms of cognition, the interviewees emphasized that learners should have a deeper understanding of the history of art and of the patterns and trends of the art market in

modern society. Such cognition is conducive to the confirmation of future creation and the development positioning of art apprentices, in other words, during the learning process, the art apprentices should also begin to think about and define their own position in the art market in order to determine the potential future development.

Finally, affection is regarded by the interviewees as the most central and important high-level educational goal in the learning process. If inheritance education can achieve the learning goal of affection, it signals a change in the personality, character, attitude, and values of the art apprentices. Judging from the connotation of its educational orientation, it includes understanding and recognition of the cultural context of the development of lacquer art craftsmanship, the sense of mission of inheritance education, the values, and the ability to comment on the formation of creative ideas, etc. In addition, the current "Transmission and Preservation Project" implemented by the Bureau of Cultural Heritage for allows preservationists or preservation groups to submit their own implementation plans, and the training period is three to four years, starting from the training of basic skills, and through continuous practices and creation, the students become capable of creating and interpreting artworks independently. The lacquer art conservator who participated in this project said: "The development of lacquer art in Taiwan is different from Japan's single-technology specialization, since the development of lacquer art in Taiwan is rather late, so the creation of lacquer art artists in Taiwan usually incorporates different techniques, resulting in a special style of lacquer art in Taiwan. The lacquer artists often develop unique ways of presentation, using materials such as mother-of-pearl, gold leaf, eggshell, gold powder, and paste to express different color textures in their surface decorations, infusing their own spiritual energy into their works".

In this study, interviews with conservators, apprentice artists, and lacquer craftsmen revealed that the spirit of the "Transmission and Preservation Project" is in line with the traditional folk art apprenticeship system Figure 2. presents the structure of the cultural assets preserved by the lacquer art of Taiwan in the educational transmission. In the current education of lacquer art in Taiwan, primary emphasis is placed upon the cultivation of techniques, such as lacquer materials, aesthetics, painting techniques, material knowledge, and the application of composite media, etc. In this process, the students are involved in the work, creation, and even living together with the conservators. During the process, apprentices not only learn lacquer techniques and gain experience from the conservators but also learn the conservators' attitude towards the quality of their works and the constant pursuit of perfection, so as to establish a good creative attitude for the apprentices.

In the process of knowledge cultivation, the conservators often require the apprentices to diversify their knowledge acquisition, not only in terms of knowledge of lacquer art culture, lifestyle, market characteristics, lacquer materials, lacquer techniques, and development history, but also in terms of learning and reading across different craft categories. After three to four years of training, the conservators begin to guide the apprentices towards the construction of their own creative concepts, gradually moving from the stages of "capable of making", "capable of thinking", and finally "capable of self-explanation", to cultivate the apprentices' emotions and identification with the art of lacquer craft.

During the analysis process, this study also discovered that the past learning experience of an intangible cultural heritage conservator profoundly affects the teaching methods of the conservator as an educator. Although the transmission and preservation project was based on the model of "oral transmission and teaching" and the "incidental teaching method", the system of educational content still requires the Cultural Heritage Bureau to arrange professional consultants to assist the conservators, which benefits the systematization of educational content. As a young generation of transmission and preservation project art apprentices, they also achieve the mission of organizing the experience and knowledge of the cultural heritage conservators throughout their lives. The interviewee, the Deputy Secretary of the Cultural Heritage Bureau, believes that intangible cultural assets are similar to an organic body in the context of cultural development, which grows and declines depending on the time and space. However, intangible cultural assets are

inherited by "people", and when a cultural asset preserver passes on his or her knowledge, skills, and feelings to the next generation, we should keep an open mind and let it develop naturally!

4.2. The Value Level and Learning Level of Lacquerware Art

In addition to the educational strategy of lacquer art in the previous paragraph, this study analyzes the in-depth interviews and textual data from the viewpoint of educational and artistic connotations during theoretical development. It is expected that through the expert meeting strategy, systematic procedures will be adopted to gradually disclose the viewpoints and meanings of the content of the materials, expecting to obtain a more psychological inclination, artistic discourse, and spiritual discourse of creation.

The result of the grounded theory enables us to develop a "Lacquerware Art Learning Framework", which corresponds to the spiritual structure of arts and crafts values, as well as the creative structure. Therefore, after the expert meeting, we proposed a "Lacquerware Art Value and Learning Structure Diagram" (Figure 3) by integrating the three parts, namely, the learning structure, the spiritual structure, and the creation structure. Due to the limited space, we are unable to fully present all the details of the integration process in this study, so we have placed a comprehensive and simplified Table A1 of the "Lacquer Learning Framework Code" in the Appendix A of this study.

From reflections taken at the expert meeting, we attempt to unveil the connotation of the artistic value of lacquer art and the learning levels of the trainees. This study concluded from the expert meeting that the lacquer artists' contemplation of the craft levels echoes the three extremes of the Tao system in the *Book of Changes* as well as the core of Lao Tzu's *Tao Te Ching*, which quoted "The Way gave birth to one. One gave birth to two. Two gave birth to three. Three gave birth to all things. All things carry yin and embrace yang. They reach harmony by blending with the vital breath". The "Lacquerware Art Value and Learning Structure Diagram" is summarized as shown in Figure 3 below:

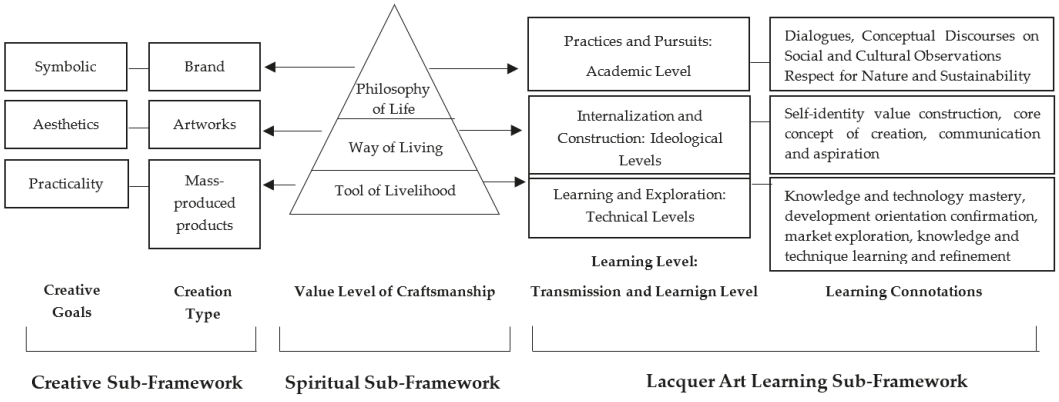

Figure 3. Lacquerware art value and learning structure diagram.

Lacquerware art preservation is not only the cultivation of techniques and knowledge but also the process of cultivating the personality and character of the art apprentices. The value level of creation can be divided into three levels: livelihood, living, and life.

The "Tool of Livelihood" corresponds to the level of learning, where the emphasis is on the cultivation of knowledge and skills of the art students. During the training, the interviewees, who are the preservers of lacquer art in Nantou County, said that in the process of learning lacquer art, they must rooted in their fundamental lacquer art skills and abilities so that they might be able to connect with the market and maintain their livelihoods after graduating. The "tool of livelihood" level is achieved in basic

education and learning, which focuses on the cultivation of the knowledge and skills of transmission and preservation project art apprentices. First of all, the basic ability of art apprentices to integrate into the market to make a living after graduation is the main focus. In terms of lacquerware art, it is necessary to be familiar with the process, master the characteristics of various lacquer liquids, flexibly applying various tools and composite materials, and practice on different carcasses. The lacquerware art decoration techniques include lacquer applying, delineation, embedding, Maki-e, the Raden technique (it is a technique in which pieces of shell are attached to the surface of the carcass and then grinded to produce the characteristic color of the shell, and it is called "Luo-Dian" in Chinese,) multiply lacquer layers, stacking, and etching carved lacquer, etc. The surface of lacquer crafts can be treated with delicate painting techniques revealing different colors through different procedures such as polishing, delustering, and consider the texture, natural texture, cracks, and other variants. There are more composite materials such as jade, gold leaf, mother of pearl, eggshells, etc. These embellishments and decorations are the reasons that make lacquerware art unique and varying in visual changes [22]. In addition, learning at this stage needs to cultivate the market demand and consumption characteristics of the domestic and international markets. From the interviews we learned that even the cultural heritage conservators continue to emphasize innovative expressions and visual symbols in each creation, which is also one of the critical points of inheritance education. Such an attitude of constant search for newness, change, and improvement is one of the key points of heritage education.

The "Way of Living", proposed in Figure 2, the Lacquerware Art Value and Learning Structure Diagram, discusses the internalization of knowledge and skills by creators, who can gradually construct their creative values and beliefs and communicate their ideas and demands with the market in the form of art collections. Artistic literacy stems from the combination of beauty and philosophy. It has gradually moved away from daily necessities and artifacts in the mass consumer market and towards art collections with conceptual expressions, echoing people's yearning for life attitudes and lifestyles. The interviewee, who is a lacquer artist, said: "Lacquer art itself is an extraordinary craftsmanship, and students must recognize this and be determined to continue creating. It is important not to go overboard with superficial, superficial, experiential learning for a short period of time, and that is why the 'transmission and preservation project' must be at least 3 years long".

Due to the creative process of the lacquer process, it is necessary to continue the repetitive process of painting, polishing, repainting, and re-polishing, which has become the process of cultivating temperament, internalizing emotions, and comprehending the truth. Therefore, the highest level of value demonstrated by lacquerware art craftsmanship is the "Way of Life".

In the "Philosophy of Life" level, creators have transcended the market mindset and emphasized self-practice instead and express their views and respect for society, culture, and ecology through their works. The interviewees who used basket as a form of lacquer art creation said, "our inspiration and materials are all from nature, and many crafts in Taiwan are are taken from nature and used in nature. Creation itself is symbiotic, coexisting and in dialogue with nature, such as bamboo art and lacquer art. The work will eventually decay and return to nature, just like each of our existence in the world. At such a level, art has transcend into beliefs that the art apprentices may carry on to preserve these intangible cultural heritage through their skills, and with such belief this will be the motives for future preservation, activation, innovation, and pass on as a lifelong task so that the skills can be passed on sustainably". [Figures 4 and 5 (photographed by author)].

Figure 4. The lacquer art cultural heritage conservators interviewed for this study: Qing-Shuang Wang. The interviewee personally demonstrates the drawing process and technique.

Figure 5. The lacquer art cultural heritage conservators interviewed for this study: Lee Rong-Lieh, the interviewee who combines bamboo art with lacquer art to create the art form of "basket lacquerware".

5. Conclusions and Suggestion

Due to the modern lifestyle, traditional cultural heritages are rapidly vanishing due to changes in market characteristics. Taiwan has been promoting projects related to the inheritance of intangible cultural assets for more than 30 years. This study focuses on the "Transmission Project for Important Traditional Arts Preservationists and Preservation Groups" implemented in recent years as a case study. The cultural heritage conservators, art apprentices, craftsmen, and public sector personnel who have promoted the project were invited to conduct in-depth interviews.

The study conducted a grounded theory analysis by means of expert meetings and proposed "Lacquerware Art Passing-on Education Framework Diagram" and "Lacquerware Art Value and Learning Structure Diagram" containing three sub-frameworks: "Lacquer Art Learning Sub-Framework", "Spiritual Sub-Framework", and "Creative Sub-Framework" in response to the research objectives and analyze the strategy of art craft education in Taiwan's lacquer craftsmanship inheritance education, as well as the value level and learning level of lacquer craftsmanship. However, there are many types of craftsmanship with different cultural contexts and social relations, processes, techniques and tools, and deep knowledge systems, which are topics worthy of future research.

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Appendix A

Table A1. A synthesis of learning framework codes compiled from grounded theory (Simplified Table).

Selective Coding	Axial Coding	Open Coding
Learning and Exploration: Technical Levels	Development Positioning Confirmation	• Positioning for the future based on aspects of the market • Positioning style from the technical aspect and expression • The choice of carrier for the presentation of lacquer art • ..., etc.
	Exploring the market	• The Development of Lacquer Craft • Marketing nature of lacquer art creation • Characteristics of domestic and international markets • ..., etc.
	Knowledge and Technique Learning and Refinement	• Understanding and production of lacquer materials, painting techniques, surface treatment techniques, composite materials • The production and characteristics of the body • Observation of nature • ..., etc.
Internalization and Construction: Ideological Levels	Self-identity value building	• Lacquer art is an ultimate craftsmanship, and students must have this understanding and the determination to continue creating • To learn the concepts and techniques of national conservator and to take on the mission of preserving culture • ..., etc.
	Creation Core Concept	• The shape of the body, whether it is flat or three-dimensional, it already has the existence of a theme • Lacquer art can be a decorator for different kinds of artworks. • The creator must pour his spirit into the work • ...etc.
	Communication and Aspiration	• Artwork needs to find a market, whether it is an artistic market or a commercial market • The traditional market has traditional cultural patterns that are accepted, and after modernization, new patterns and new meanings emerge. • In the face of the changes in modern life, how can artworks speak to the modern public? • ...etc.

Table A1. *Cont.*

Selective Coding	Axial Coding	Open Coding
Practice and Pursuit: Academic Level	Philosophy	• At the end of the day, the art apprentice may also become the next preservationist, and at this time, he or she must develop his or her own set of discourses. • Such cultural skills must be passed on to the next generation. Of course, at this time, you will have your own teachings, and you will also tell the next generation about your insistence on the art. • ...etc.
	Respect for Nature and Sustainability	• Before painting, you must sketch, which is a kind of atmosphere given to us by nature, and it also tells us that everything comes from nature. • Lacquer art is made from the most natural materials, and many crafts in Taiwan are like this. It is taken from nature and used in nature, just like the creation, it is also a symbiosis, coexistence and dialogue with nature, and the moment the work disappears, it is also a return to nature, just like we all exist in the world. • ...etc.
	A Dialogue of Social and Cultural Observations	• Only when there are people can there be art. In other words, art is appreciated by people, art is interpreted by people, and people are moved by art, and artists are in dialogue with people in this way. • Honestly speaking, the craftsmanship itself is similar, like the high Maki-e painting in lacquer art, which actually has the same concept as the three-dimensional sculpture and carving, especially the aesthetic sense itself is similar. You wouldn't say that the way I create lacquerware is not related to the way I think about sculpture, would you? • I think if a craft is not able to sustain its livelihood, then it will be eliminated sooner or later. The "Transmission and Preservation Project" has contributed to the education of the heritage, but it still has to return to the creator himself, how to take this craft and create a dialogue with the modern society and culture. • ...etc.

Note: Due to the limitation of space in this article, the contents of this table have been simplified and presented in the form of extracts of highlights.

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Education in Cultural Heritage: A Case Study of Redesigning Atayal Weaving Loom

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Abstract: Employing cultural ergonomics concepts to product innovation for cultural education and sustainable development is the target of this study. Atayal culture is famous for its weaving craft and art. The Atayal tribe of Taiwanese aborigines weave on the Atayal loom. Traditional culture is disappearing rapidly due to colonial history and modernization. The Atayal people consider the weaving loom a cultural object when used as a weaving device. This study attempts to transform the ancient Atayal loom into a teaching device and extend Atayal weaving from execution in daily living to cultural experience and cultural heritage development. This study first explores and identifies the meaning of cultural objects and extracts their cultural features. Then, employing cultural ergonomics, a weaving box is redesigned from an ancient part of the loom into a modern weaving box. Finally, the new weaving device is evaluated and discussed. This case study examines a paradigm of how designers interact with cultural heritage and transform cultural objects into new instructional aids. Through cultural product design, it provides an intertwined experience in theoretical and practical approaches to accomplishing the development of cultural sustainability.

Keywords: cultural ergonomics; cultural education; Taiwanese aboriginal culture; product innovation; cultural sustainability

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1. Introduction

Due to the multiple impacts of globalization, aging society, and COVID-19, the continuation and recovery of aboriginal cultural heritage and local revitalization have become more and more important in the creative industry and sustainable development [1,2]. These critical challenges of aboriginal communities and local economies rely on the integrated knowledge of traditional culture and abundant ecology dedicated to regional resilience [3–6]. Most aborigines believe that sustainability results from respect for nature; they strive to preserve that balance for the next generations. For instance, by listening to the birdsong of the grey-cheeked Fulvetta, the Atayal, one of the indigenous tribes in Taiwan, determine the best moment for executing each significant activity. This bird divination (*Mita siliq*) is the traditional behavior of the Atayal ritual, and attaches emotional attribute to an external object. Aborigines used to learn from nature and obey natural orientations.

Aborigine cultures have contributed to local industries as well as sustainable development. Successful cases in Australia and the United States inspired the authors and triggered this study [7,8]. There are sixteen indigenous tribes in Taiwan, all with diverse characteristics [9]. Following the traditional belief system, spiritual guidance, and social rules of Gaga, the indigenous peoples stress harmony and symbiosis strategies between

humans and nature [10]. As well, sustainability has already become a vital issue in aboriginal communities. It calls for simultaneous and multiple considerations of the environment, society, economy, education, culture, etc. [2,10,11].

Moreover, enhancing cultural education has become increasingly crucial for the sustainable development of aboriginal and traditional cultures in recent decades in Taiwan [2,9]. The result of creative thinking and creative education can be facilitated with the help of practical learning tools [12]. The study of cultural education usually focuses on methodology-based learning. However, this study proposes a methodology-driven project practice that composes methodology-based and project-based advantages [13]. Accordingly, the authors dedicate themselves to integrating the understanding of cultural context into the design process of transforming the innovational product [14].

Based on previous studies [15,16], this article intends to explore and apply the concept of cultural ergonomics to cultural product design for instructional aids. This study redesigns a desktop loom to provide novice weavers with a valuable and tractable device for weaving a successful cross-cultural product and achieving the balance between traditional heritage preservation and innovative education for culturally sustainable development. First, this study attempts to comprehend and illustrate the original meaning of the Atayal weaving loom. Then, the study extracts the cultural features and transforms them into a modern product of weaving boxes by employing the concept and paradigm of cultural ergonomics to product innovation. Finally, the new weaving box is evaluated to offer a convenient learning aid for education in cultural heritage and reflect on its support for promoting sustainable development.

2. Literature Review

2.1. Atayal Weaving Culture and Multiple Identities

The Atayal tribe is famous for its weaving craft and art; however, the weaving culture is disappearing rapidly due to the impact of the colonial period and modernization [9,17,18]. The efforts of cultural revitalization and the reintroduction of traditional weaving have had multiple effects on the contemporary Atayal communities. As a distinguished and significant symbol of aboriginal cultural heritage, Atayal weaving has recently been used to promote regional tourism in Wulai, the small township of northern Taiwan. Nonetheless, the Atayal tribe is barely involved with the tourism business or relative planning [18,19]. Thus, these situations remind rulers, scholars, and designers to re-clarify the purpose of local revitalization and reflect on achieving sustainable development and promoting local culture industries through cultural product design and education. However, in order to meet changing trends, technological progress, and commercial needs, new weavers and weaving studios try to embrace and merge traditional convention and creative invention. They hope to balance production and textile marketing and create different possibilities for future development [19]. Therefore, the sustainable development of the Atayal weaving culture continues to have potential, and the Atayal loom is deserving of in-depth study [18,20].

Today, the ritual patterns and meanings of facial tattoos can be transformed into new visual motifs through cultural education associated with user experience and emotional design. In this way, the unique culture of indigenous groups is presented to the world in a new form, which helps to perpetuate this cultural education. When balancing local cultural industries, understanding and integrating traditional and environmental knowledge are essential for achieving a sustainable future [21].

During the colonial occupation, the Atayal were forced to abandon their vital socio-culture activities; more exactly, they were prohibited from weaving, facial tattooing, and headhunting [22]. Meanwhile, some Atayal women reconstructed their textile culture by weaving for museums, and others were involved in the local market by weaving for tourists [18]. However, hand-weaving struggles to compete with factory-made woven products, especially considering the confusion of cultural identity. Nevertheless, there are multiple identities and effects on the Atayal community that take place through the reintroduction of its weaving culture. There are profound meanings and various identities

involved in weaving reconstruction, including weaving for living, gender identity, ethnic, cultural, and place identity, and collective ethnic identity as the Atayal [18,19,22]. As Yoshimura [18] has indicated, the revitalization of Atayal weaving not only required weavers to retrace their weaving history or revive lost skills, it required them to explore new opportunities to create new motifs, especially by adopting imported looms or new weaving devices [18,19,23]. Today, the Atayal proudly claim their weaving culture not only, as usual, as a matter of gender identity among Atayal females, but as the collective ethnic identity of all Atayal [18].

2.2. Cultural Ergonomics in Atayal Loom

In traditional Atayal society, operating a weaving loom to accomplish weaving tasks is women's most important skill and mission [17,22,24,25]. This study focuses on a weaving loom, the Atayal ground loom with a back strap, shown in Figure 1. We employ the subject of the Atayal weaving box to explore cultural ergonomics based on a systematic and scientific approach. According to the physical needs of weavers and their tribe's custom, the width of the weaving box can be from 60 to 90 cm. Usually, the wooden box is made from the wood of the Camphor tree, Beech tree, or Formosan Michelia tree because of their properties of sturdiness and firmness [17]. The continuous warp threads go around the weaving box, completing the circular path, and are fastened by a pair of cloth beams held near the weaver's body by a strap secured at each end and passing behind her back. The weaver sits on the ground and presses her feet on the major part of the Atayal loom, the weaving box, sometimes called the warp case, to alternately tighten and loosen the tension of the warp threads. Utilizing the strain and relaxing the warp threads to regularly create an open shed, the shuttle passes the horizontal weft thread through the vertical warp threads repeatedly until the patterns and cloth are woven completely [17,23,26].

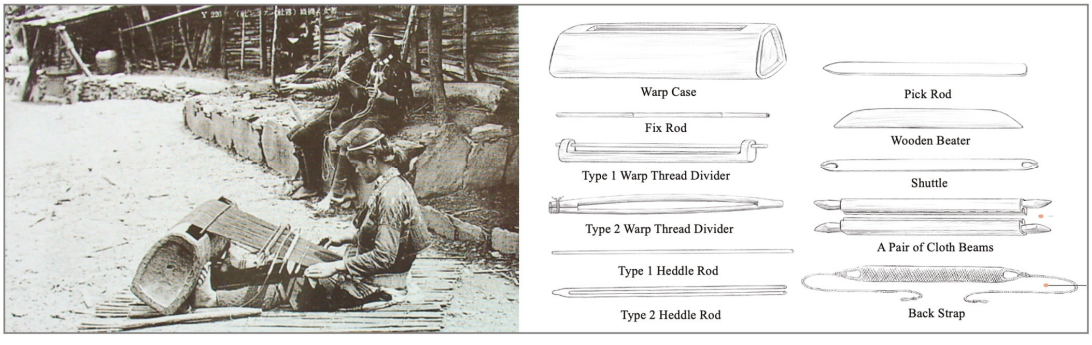

Figure 1. An Atayal woman weaving on her backstrap loom. (Adapted from (**left**): [26]; (**right**): [17]).

In conjunction with the analysis framework of the human–system design, the authors argue that an ergonomic study of the Atayal weaving box should employ the user–tool–task paradigm [21,27–29]. Essentially, through detailed analysis and discussion to realize the weaving loom design, the interaction and feedback among the three objects of user (weaver), tool (weaving loom), and task (weave cloth) are explained, as shown in Figure 2. First, the "manipulation interface" (ergonomics) between the user (weaver) and tool (box loom) is analyzed. The review of user-friendly factors that exist in the user–tool interface includes the concerns of operability, portability, safety, comfort, etc. Second, the "engagement interface" (technology) is clarified in order to identify the relationship between the tool (weaving box) and the task (weave cloth). Examination of tool-usable aspects harbored in the tool–task interface involves consideration of the box shape, tool storage, suitable materials, haptic sensation, etc. After ergonomics research and human factors analysis, this study obtains practical results and understandings about the interrelationship between the weaver, Atayal box loom, and weaving product.

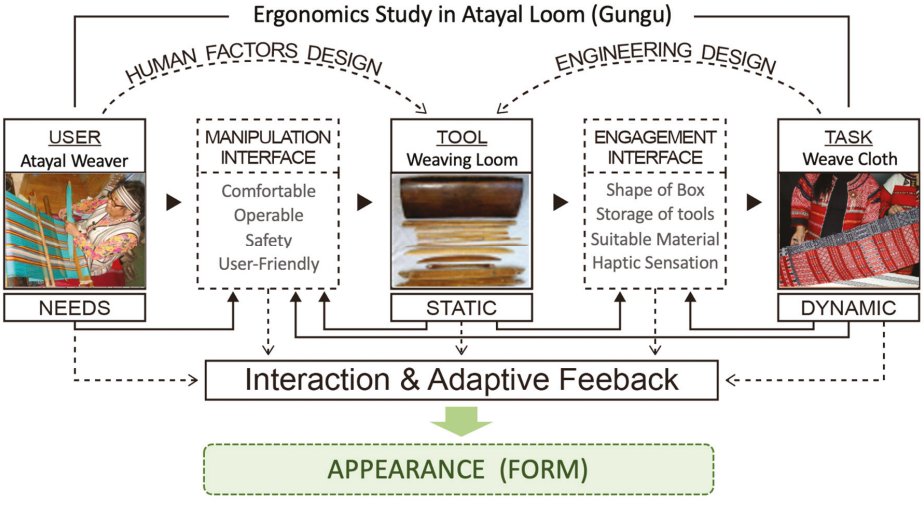

Figure 2. The analysis framework of the ergonomics study of the Atayal loom. (Adapted from [21,27]; redrawn for this study).

The weaving loom has been used in the traditional Atayal tribes for centuries. Recently, under the impact of globalization and the aging community, people have retraced and rethought the meaning of Atayal weaving culture to respond to the concerns and demands on cultural identities and sustainable development [17,18]. Meanwhile, in addition to applying human system design, adopting a cultural ergonomics approach is necessary to explore human–cultural interactions, extract their cultural characteristics, and transform them into modern products for preserving aboriginal culture [30–32].

Based on the experiential interaction with weaving loom and combining the user–tool–task model (Figure 2) with the above scenario, a framework that enhances understanding of cultural ergonomics in developing the cultural product design related to the Atayal weaving box is illustrated in Figure 3 [27,30]. In the case of the weaving loom, "scenarios" indicate the need to operate a weaving loom to weave textiles for daily life or specific dress for particular events or ceremonies. Moreover, "factors" refer to the loom's function, timing of usage, operating location, user experience, etc. Finally, "levels" provides attention to the specific formation, interactive behavior, and cultural meaning of the weaving loom [31]. From the perspective of cultural ergonomics, the development of the Atayal weaving loom comprises three levels [33]. First, the outer level (user) focuses on the weaving loom formation related to the user's demands, lifestyle, and feelings. Second, the middle level (tool) connects to everyday life function, usability, and behavior regarding the weaving loom. Third, the inner level (task) reflects the cultural meaning of the ceremony, reflection, and emotion derived from the weaving loom [30,31,34–37].

The integration of human–system design (Figure 2) and cultural ergonomics (Figure 3) facilitates weavers to improve textile quality and enhance productivity. Furthermore, ergonomics knowledge helps to prevent cumulative trauma to weaving laborers' health. For example, apprehending and sympathizing with aboriginal weavers in Guatemala, Piegorsch [39] designed an adjustable bench and provided an additional way to reduce suffering in the traditional weaving process by employing cultural ergonomics knowledge and strategies. Moreover, based on this empirical study, she proposed a cycling approach with five stages: health, productivity, quality, culture, and self-esteem. Similarly, the traditional weaving posture of sitting on the ground for a long time causes cumulative trauma of the back to Atayal weavers. Moreover, many studies have evaluated the prevention of low back pain among handloom weavers [40,41]. Atayal people have recently sought alternative ways to weave and transform weaving art for extending Atayal culture. Thus,

the present study employs the weaving loom as a case study in order to illustrate how to transform cultural features and design a cultural product that can aid cultural learning.

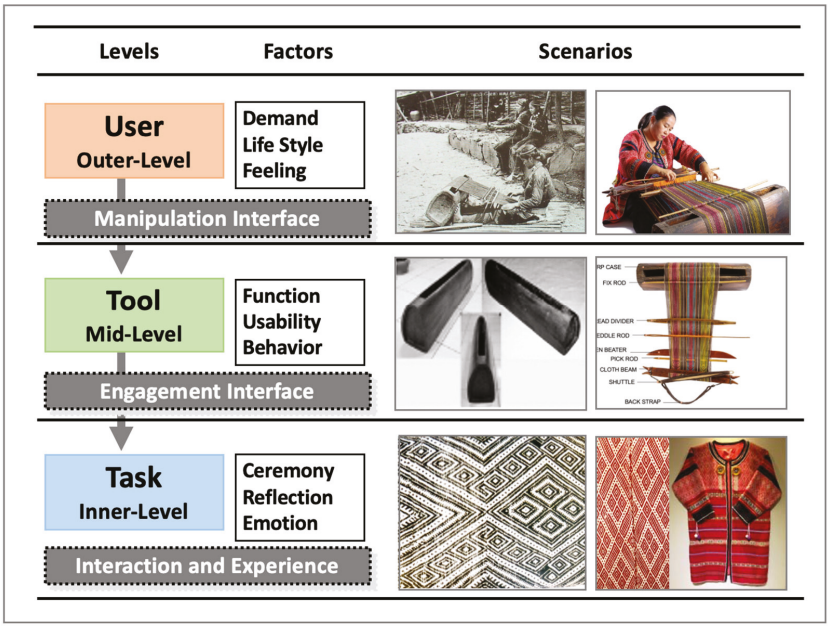

Figure 3. Cultural ergonomics in product design with scenarios relating to the weaving loom. (Adapted from [26,31,38]; redrawn for this study).

2.3. Transformation and Inkle Loom

The date of the first loom can be traced back to the ancient Egyptians and Greeks [42]. In the archaic period, there were three major weaving devices: the horizontal ground loom, the vertical loom with winding beams, and the vertical loom with warp weights; of these, the ground loom is the oldest and most historical type [43,44]. The Atayal loom is one of the original portable backstrap types that belong to the horizontal ground loom category [17,45]. In the past, Atayal weaving was a delicate and meticulous mission. Usually, the weaving yarns were made from ramie and dyed with specific herbs. After ripping, cleaning, drying, and poaching, the ramie threads could be used for weaving. With changing technology, now Atayal people use wool or cotton in weaving instead of ramie [17]. Numerous tools were necessary during the traditional procedures of Atayal weaving. Relying on their professional and ingenious weaving skills, Atayal women created beautiful cloth [46]. However, due to the complicated instruments and overweight tools, the traditional weaving apparatuses are not convenient for fetching and carrying. Inevitably, the continual posture of sitting on the ground for hours hurts the back and waist of the weaver. Thus, seeking alternative ways to resolve problems related to traditional weaving for its cultural creation and sustainable development has become urgent for the Atayal people [17,47].

To reduce the trauma on indigenous weavers caused by the traditional ground loom, the American Catholic Fathers imported the New Zealand floor-standing loom to Taiwan in the 1960s [48]. Later, a new type of table-top weaving device was invented known as the desktop "Inkle loom". When operating the desktop inkle loom, the weaver manually controls the lifting and lowering of warp threads to create the shed for the weft threads to shuttle through and accomplish weaving tasks [49]. The term "Inkle" refers to the "tape" or "ribbon" used by such looms. The inkle loom is usually used for weaving narrow works, and is suitable for straps, trims, belts, and narrow bands [50–52]. Because of the

convenience and portability of the desktop model, inkle weaving became very practical and efficient in operation and promotion. There are five major parts composing the setup for table-top Inkle weaving, as shown in Figure 4.

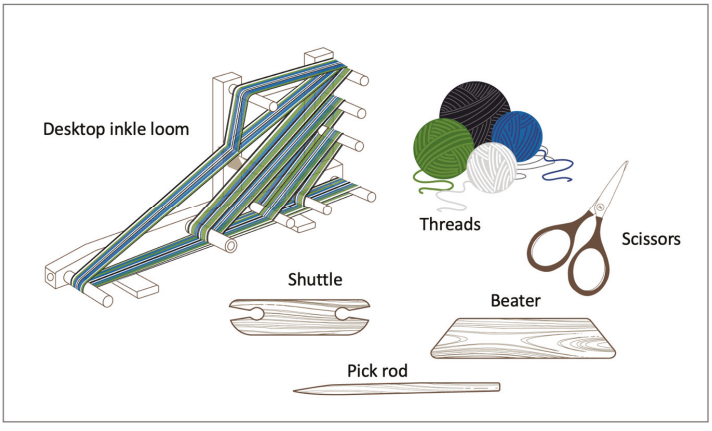

Figure 4. Major apparatus and materials for inkle weaving. (Source: this study).

The specific instructions are as follows. (1) Desktop inkle loom: this is the foremost part of the table-top weaving equipment, and substitutes the vertical thread sorting shelf. (2) Beater: this is used to push weft threads tightly together. (3) Shuttle: this is made from bamboo or wooden pieces; its primary function is to carry the weft thread between the warp threads. (4) Scissors: used to cut vertical and horizontal threads. (5) Thread materials: vertical (warp) and horizontal (weft) threads for weaving [26].

Typically, cultural products have been regarded as souvenirs for tourism in the cultural industry system. Most are imitations or counterfeits of native products without authorization from the aboriginal tribe [53]. However, indigenous women have handwoven Atayal textiles for the exhibitions in the Wulai Atayal Museum following its opening in 2005. The museum displays its materials and traditional artifacts and organizes the weavers to perform live demonstrations in order to show the tribe's techniques at sightseeing attractions [17]. The museum is diligent in promoting and selling the works made by the weaving association members. It selects talented members as its instructors to design and execute cultural learning activities, such as DIY programs inspired by the user experience strategy [17,54,55].

The new type of table-top Inkle loom is convenient for strap creation or promoting cultural learning by employing ergonomics strategies that foster user experience. Indeed, the imported loom already has had effects on modern Atayal weaving [18]. The new desktop loom changes the way of sitting or standing to weave directly by penetrating the shuttle in order to create beautiful patterns. Furthermore, the new type of loom is much more time-saving than the traditional ground loom in weaving textiles, and it has become a popular tool for modern indigenous peoples seeking to revive the weaving crafts and arts [48]. However, the preparation and procedures required for the new imported weaving loom nonetheless takes time and space. As a result, in the native education of Atayal weaving courses and learning activities, the primary school and local workshop can only teach students vertical thread sorting and strap weaving by the Inkle loom [17,56] because of empirical limitations on practical learning, especially time limitations, apparatus storage, operation ergonomics, and culture transmission. This study argues that the imported desktop Inkle weaving device for Atayal cultural learning needs to be reviewed and redesigned by applying cultural ergonomics [26]. By enhancing our understanding of cultural meaning, cultural ergonomics contributes to contemporary cultural research and education through improved design implementation and product innovation [57].

3. Materials and Methods

3.1. User, Tool, and Task

Similar to the other indigenous people in Taiwan, after suffering from the extermination of traditional tribe culture in the past colonial period, the Atayal people have been trying to retrieve their textile tradition and weaving culture by tracing back and relearning from their ancestors' wisdom [19]. Thus, this research examines three essential objects connected with this design case of Atayal Weaving loom transformation from the cultural ergonomics perspective: users with distinct concerns, tools in various eras, and tasks for different expectations.

- User (expert/novice): Yuma Taru is an outstanding weaver and prominent artist from the Atayal tribe in Miaoli County. She is one of the most important spirits who inspired and facilitated this empirical research. With her workfellows, they not only have worked to preserve the Atayal weaving tradition for decades, they have endeavored to extend the Atayal weaving arts to modern audiences. In the past, the Atayal tribe utilized oral transmission without literal writing. Thus, daughters had to learn their weaving knowledge from their mother's in-person instruction and verbal description, which all relied on excellent memories. Through their efforts, much of the abundant data and special presentations about beautiful aboriginal patterns have been preserved in modern weavers' notation [17,26,58]. Furthermore, Taru is trying to improve a school for the impoverished village children on the hills above Miaoli, and has established the Lihang workshop as a cultural center to promote Atayal cultural learning and creation [59]. While Taru was teaching the Atayal loom at the Lihang workshop in Miaoli, several children were attracted and wanted to know how to weave. Taru realizes that the classroom situations in rural primary schools need to be greatly improved for effective cultural learning, especially regarding cost, budget, space, and suitable devices. She believes that through such improvement, children and beginners will have a fair opportunity to learn and enjoy a relatively inexpensive and easily-learned introduction to this valuable and enjoyable art and craft. Thus, in this study, kids from the rural primary school are the major participants invited to operate and compare two kinds of new inkle devices.
- Tool (object/product): The Atayal traditional weaving box (Figure 1, before), called a weaving loom in the Atayal language, is the subject of this study. In the studies and reviews in Section 2 this study illustrates the relations and interactions in the three cultural levels, as shown in Figures 2 and 3. One of the characteristic appearances of the Atayal traditional loom is its wooden box with storage space, called a warp case. Its primary usability is recognized as a fundamental part of the Atayal horizontal backstrap weaving loom. However, the weaving posture of sitting on the ground usually causes cumulative trauma to the weaver's back and waist. In brief, the cultural meaning of the weaving loom is its symbolization of multiple identities: gender identity among Atayal females in the past, and the collective ethnic identity of Atayal culture today [18,19,22]. Thus, this research argues that the Atayal loom is a cultural object that could be transformed from a traditional weaving tool into a cultural product.
- Task (weave/experience): In the past, Atayal people had to weave textiles for daily life and specific dress for particular events and ceremonies. In contemporary times, Atayal people have woven for museum displays or tourism markets. In the ancient period, Atayal people wove textiles with tribal patterns. Recently, the Atayal and their fellow tribal people keep trying to retrace their ancestors' wisdom and revive local communities. Although they are from different generations, most of these weavers are looking forward to accomplishing their life duties or artistic ideals by weaving. In addition to weaving for their livelihood, museums, or markets, other concerns may include seeking alternative ways to pass on their inherited traditions and preserve their culture. Today, the Atayal proudly claim that the weaving culture has been recognized as the collective ethnic identity of the Atayal [18]. As Kreifeldt

has mentioned, the artifacts of a culture are its external expression, and our modern products need a connection with a spiritual foundation [60]. Thus, according to the preceding discussions and looking into the future, this study extracts and re-identifies the adaptive meaning of "weaving loom" culture as "weaving for pleasure" conducted with the user experience strategy to meet demands and balance in the new era. This study expects the redesigned modern weaving box to facilitate and propel the improvement in tribal culture learning capably both affordably and sustainably.

3.2. Design Transformation

3.2.1. Sustainable Model of the Cultural Ergonomic Cycle

Applying the concept of cultural ergonomics, Lin et al. [31] proposed a cultural research framework to provide a valuable reference in cross-cultural product design. Based on previous studies [21,31,53], the present study organizes an empirical model of a cultural ergonomics system with a sustainable cycle, as shown in Figure 5. The circulatory research model consists of two primary circles: human–system design and the cultural ergonomic approach, as well as three essential sections: cultural object, design transformation, and cultural product.

The first circle (Figure 5, left) analyzes the influences and interactions of the user–tool–task paradigm and emphasizes the three subjects of design: user (human), tool (cultural object), and task (goal) along with the two interfaces: manipulation interface (ergonomics) and engagement interface (technology). The second circle (Figure 5, right) places cultural ergonomics in the core. It reconstructs the three subjects on different cultural levels (user on the outer level, tool on the middle level, and task on the inner level) into an mutually supporting triangle.

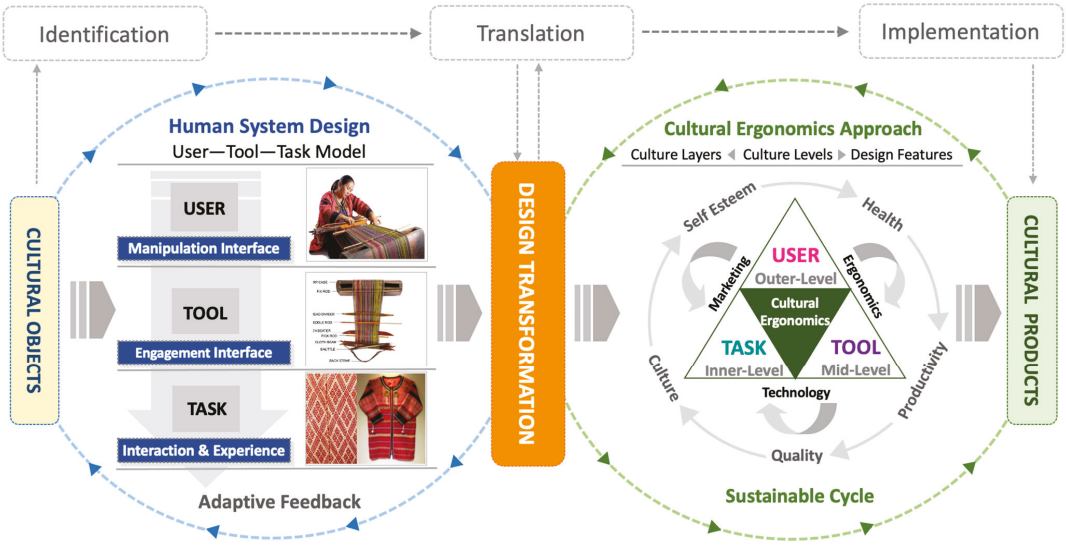

Figure 5. Sustainable model of cultural ergonomic cycle for Atayal loom. (Adapted from [17,31,38]; redrawn for this study).

After the human–system design method analyses, as shown in the first circle (Figure 5, left), the "cultural object" is identified in its historical context with a contemporary perspective. The designers keep discussing the design information and extracting the design elements when they move on to the next stage of design transformation (Figure 5, middle). In addition to applying and integrating the cultural ergonomics approach, as shown in the second circle (Figure 5, right), the "cultural object" (traditional Atayal loom) is redesigned and transformed into a new cultural product (modern weaving box). This

model proceeds with three steps: (1) Identification: extracting cultural features from the original cultural object; (2) Translation: translating the features into design information and design elements; and (3) Implementation: designing a cultural product. Moreover, the redesigned cultural product may subsequently be recognized as a valuable inherited cultural object in successive generations, thereby repeatedly returning through the cycles to launch the continuous circulation of cultural ergonomics research and accomplish the sustainable development of cultural design, learning, and diffusion.

3.2.2. Transforming the Traditional Atayal Weaving Loom into a Modern Weaving Box

This case study of the Atayal weaving box adopts the sustainable model of the cultural ergonomic cycle and mainly executes three steps of the design transformation process: (1) Identification; (2) Translation; and (3) Implementation (Figure 6).

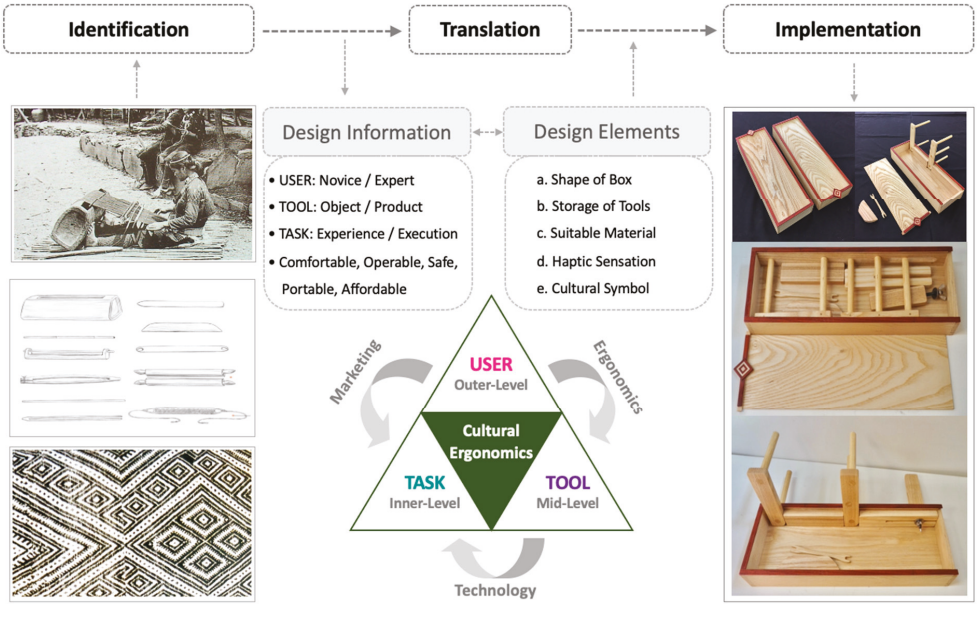

Figure 6. Design transformation process of Atayal weaving box. (Adapted from: [17,26]. Redrawn for this study).

- Identification: This study retrospect and discriminates the significant meaning of the Atayal weaving culture and traditional loom (Figure 6, left). Based on previous research, this study identifies the Atayal weaving culture and cultural object (weaving loom), in terms of both gender identity among Atayal females and the collective ethnic identity of the Atayal.
- Translation: Based on the cultural ergonomics approach, this study analyzes the interrelations between the cultural subject (Atayal weaver), cultural object (loom), and cultural activity (weaving) from the three aspects of user, tool, and task. Integrating the historical and contemporary understanding of cultural heritage in Atayal weaving, researchers and designers extract cultural features as design information and translate them into adoptable design elements in the translation step, as shown in Figure 6. Before weaving on a loom, the traditional Atayal preparations (planting the ramie, harvesting, stripping, spinning, poaching, dying, sun curing, sorting, etc.) require laboring and toiling with mind and body, undoubtedly taking much time. As a result, school instructors can only teach students vertical thread sorting and simple weaving procedures on a modern loom. Due to the practical limitations (time, space, budget,

etc.), a simple device such as a desktop Inkle loom (Figure 4) is convenient and suitable for teaching weaving in school or a workshop.

- Implementation: Following the cultural ergonomics approach, this study redesigns a cultural product (Figure 6, right). The authors intend to inherit and transfer the box form and function to fulfill the appearance, storage, and portability connections between the original loom (cultural object) and creative box (cross-cultural product). In addition, while the lozenge on the cap of the outer box is used functionally as a grip handle, it additionally suggests the eye of the ancestors, which has great symbolic spiritual meaning. This single diamond shape with red striped patterns and decoration with a red frame carries ritual and religious meaning, and is an essential cultural signification in Atayal tradition. The user can manually assemble and install this re-designed product with the simpler weaving apparatus. This study demonstrates three steps of design transformation from a traditional Atayal warp case to a modern weaving box (Figure 6).

3.3. Evaluation Methods and Processes

In this case study, a weaving box is redesigned for sustainable development in cultural education to be suitable for primary schoolchildren's weaving practices and cultural learning. Thus, primary schoolchildren, schoolteachers, and experts were invited for this case's evaluation. In order to determine the usability and improve any defects, a modern weaving box and a New Zealand mini-ribbon loom with similar designs were evaluated together and compared.

- Surveyed schoolchildren: In this study, five aboriginal schoolchildren were invited for the evaluation, and ae coded as A, B, C, D, and E. Schoolchildren A and B were ten-year-old girls; C and D were nine-year-old girls; and E was an eight-year boy. It was the first time for all five schoolchildren to operate the modern weaving box and New Zealand mini-ribbon loom.
- Evaluation samples: This experiment evaluated a modern weaving box and a New Zealand min- ribbon loom. The bodies of both looms are made of wood, while certain parts are metal; the appearance and dimensions are shown in Table 1.
- Focus group: One Atayal teacher with more than twenty years of weaving and teaching experience, one designer with standing industry experience in product design, and five senior experts with academic and empirical backgrounds in cultural education, cultural research, and creative industry design were involved in this consulting committee.
- Evaluation objectives: Based on the records and descriptive documentation, seven experts reviewed the experiment of five schoolchildren's operation of both looms. They aimed to evaluate the efficiency of the redesigned weaving box and its effectiveness as a teaching aid for cultural education.

This evaluation experiment was conducted in a meeting room at an aboriginal primary school. All the surveyed schoolchildren had no experience using either mini-loom. In the beginning, an experienced weaving teacher taught a brief outline of the operation of the mini-looms to the schoolchildren. With approximately 5 min of practice, the schoolchildren were able to handle and master the operation procedures. After that, the schoolchildren operated the looms for another 5 min by themself. This study used a digital camera to record the teaching process and independent operation. Figure 7 shows how a schoolchild learned to use a modern weaving box, and Figure 8 shows how a schoolchild learned to use a New Zealand mini-ribbon loom. In the end, the following questions were asked orally: (1) Do you think the operation process is complex? (2) Do you think it is hard to operate the ribbon loom, and where do you think it is hard to use? (3) Which ribbon loom do you think works fine?

Table 1. The two kinds of mini-looms evaluated in this study. (Source: this study).

Loom Type	Dimension (cm) (Length × Width × Height)	Appearance
Redesigned Modern Weaving Box	Outer Box (36.6 × 13 × 5)	
	In Use (36.6 × 23 × 14.5)	
New Zealand Mini Ribbon Loom	In Use (38 × 11 × 17)	

Source: this study.

The senior scholar of this research team hosted the focus group and led the discussions in five virtual meetings. The experienced weaving teacher, who was a member of this research team, described and documented her teaching discoveries and situations in this experiment executed at the aboriginal primary school: in response to the following questions (1) Which loom is easier for schoolchildren to operate and weave? (2) Does the redesigned weaving box facilitate the weaving learning of cultural education? (3) What will be the schoolteachers' primary concern, demand, or challenge when executing the weaving learning for cultural education? Moreover, after evaluating the possibility of the redesigned modern weaving boxes as a teaching aid, the experts of this focus group concluded with suggestions and comments.

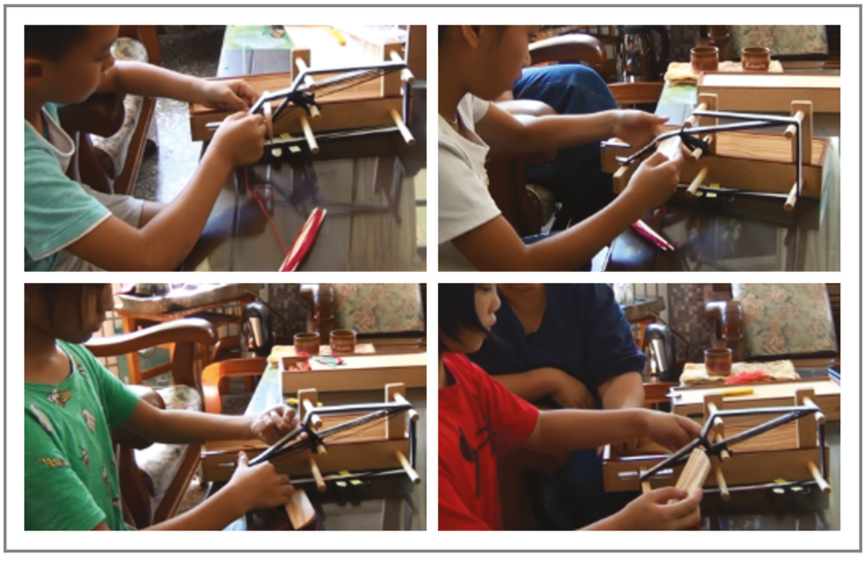

Figure 7. Process of how a schoolchild learns to use a redesigned modern weaving box. (Source: this study).

Figure 8. Process of how a schoolchild learns to use a mini-ribbon loom from New Zealand. (Source: this study).

4. Results

4.1. Feedback from the Schoolchildren

After completing the weaving learning and experience on each kind of mini-loom, each schoolchild separately had a relaxed conversation with the teacher to express their feelings or opinions about the complexity of the operation, the possible reasons for difficulty, preference in manipulating, and other responses or feedback to the two kinds of the loom. The results of schoolchildren's responses are excerpted below.

- Do you think the operation process is complex?

Result: All five schoolchildren were able to operate the looms independently after about 5 min of instruction, and they responded that the operation procedure was not complex. Obviously, the operation procedures of both kinds of mini-looms were simple and easy.

- Do you think it is hard to operate the ribbon loom, and where do you think it is hard to use?

Result: All five schoolchildren considered the redesigned modern weaving box to not work well because of "small sheds." In the weaving steps, the first group of warp threads (upper warp threads) are lifted to produce a shed (opening) between the lifted and unlifted warp threads; next, a beater is inserted to hold the shed open and let the weft shuttle (carrying the weft threads) pass through the shed. Then, the beater is used to pack down the weft threads. Afterwards, the second group of warp threads (lower warp threads) is pushed down to produce a counter-shed. The counter-shed is held open with the beater and the weft shuttle passes through it. Finally, the beater is used to pack down the weft threads as before, and these steps are repeated to weave the cloth.

Result: When the schoolchildren lifted or pushed the warp threads, the sheds produced by the modern weaving boxes were small (Figure 9, left); hence, the schoolchildren spent much time finding the sheds and expanding the openings with their fingers. The sheds of New Zealand mini-ribbon looms were large and conspicuous (Figure 9, right), and the schoolchildren easily found the shed's location and expanded the openings with their

fingers. Therefore, five schoolchildren evaluated the usability of the redesigned modern weaving boxes more poorly than the mini-Inkle loom.

Figure 9. "Shed" on both mini-looms. ((**Left**): smaller on a modern weaving box; (**Right**): larger on a New Zealand ribbon loom).

- Which ribbon loom do you think works fine?

Result: As it was hard to find the sheds on the modern weaving box, all five schoolchildren thought the New Zealand mini-ribbon looms worked better. Hence, further tests shall be conducted on the relative location and distance of the redesigned modern weaving box's adjustable bar, support bar, and harness bar to help produce large sheds and aid schoolchildren in weaving more easily.

- Other feedback: Other responses and feedback to the modern weaving box included comments on the roughness caused by its handcrafted fabrication, defects in mutual conjunction, space between cylinders, length of the banister, stability of the loom, size of sheds, and storage. Selected descriptions are as follows for reference.
    1. When a ribbon box is expanded for use, and the user feels that the pull-out is not smooth, the reason being that the wooden materials are handcrafted. There are defects in positioning the cylinder used to manage the braids and box hole. Further fine grinding is required according to the tensile strength of the cylinder.
    2. During weaving, there is incline from heavy stress due to the different bearing capacities of the cylinders used for winding. The space between cylinders needs to be adjusted to enhance the stress level.
    3. The banister is too short to reach the optimum comfortable, scale and cannot fully satisfy users, especially in length.
    4. In observing the schoolchildren using the ribbon looms, it was found that the ribbon looms waggle, slide, and even incline; hence, the future design should increase their stability.
    5. During weaving, sheds must be expanded to make the weft shuttle pass through more easily. During use, it was found that the schoolchildren would turn their heads sideways to find the sheds (Figure 10), causing neck fatigue and discomfort.
    6. The adjustable bar, support bar, harness bar, and weaving tools can be stored in the redesigned modern weaving box after weaving. However, the semi-finished weaving cannot be stored in the box together, which reduces the originally-designed storage effects.

Figure 10. This schoolchild turns his head sideways to find where the shed is. (Source: this study).

4.2. Feedback from the Schoolteacher and Experts

After reviewing the records and documentation of the experiment process, the seven experts evaluating the possibility of the redesigned modern weaving box as a teaching aid summarized their suggestions and comments as follows for reference.

- Which loom is easier for schoolchildren to operate and weave?

Result: Focusing on the research objectives and experiment purposes, the experts are primarily concerned with the operatable quality of the teaching devices. According to the records and documentation of the schoolchildren's responses and the related descriptions from the schoolteacher, all seven experts agreed that the New Zealand mini-ribbon loom worked better than the redesigned modern weaving box, mainly because the "small sheds" were hard to see and find when weaving on the redesigned weaving box.

- Does the redesigned weaving box facilitate the weaving learning of cultural education?

Result: Despite the redesigned weaving box not working better than the imported New Zealand mini-ribbon loom, the schoolteacher mentioned that the redesigned weaving box transformed from the Atayal ancient loom had kept ritual symbols carrying cultural meanings and provided a functional form for cultural experience. These enhance emotional motive, reasonable representation, and accessible interaction much more, helping to facilitate weaving learning for cultural education.

- What will be the schoolteachers' primary concern, demand, or challenge when executing the weaving learning for cultural education?

Result: Raising the learning motivation of schoolchildren is the primary concern of teachers when executing cultural education in primary schools or workshops. Schoolteachers need an innovative product as an instructional aid in order to encourage the schoolchildren's learning interest. In addition, executing weaving learning for cultural education in a time-limited period is a difficult challenge.

Moreover, limitations exist in promoting cultural education in an aboriginal community. Due to the aging society, it is hard to find enough human recourse to inherit or extend the traditional Atayal weaving culture appropriately. It was challenging to find many schoolchildren without Inkle weaving experience to participate in this experiment in the aboriginal community of the impoverished village on the hills above Miaoli. Furthermore, not all Atayal women know how to weave using the traditional looms as their ancestors did, nor have the new generations accumulated enough knowledge or experience to translate the old motifs into a new subject for modern life through redesign of modern weaving boxes.

5. Discussions

This study focuses on the aboriginal weaving culture as a case study to demonstrate how to combine human–system design and cultural ergonomics in cross-cultural product design as a cultural learning tool to aid sustainable development. Based on previous studies, this study explores and identifies the meaning of aboriginal objects. The designer extracted the cultural features from the traditional Atayal "weaving loom" and redesigned a modern weaving box. Schoolchildren, schoolteachers, and experts evaluated and discussed this redesigned modern weaving box. It was found that the redesigned modern weaving box needs improvement to address several ergonomic problems.

Despite these drawbacks, this case study provides interfaces and references for examining how designers interact with cultural objects and the interwoven experiences across cultures. Furthermore, the circulatory paradigm (Figure 5) proposed by this study and the evaluation and discussion executed with schoolchildren, schoolteachers, and experts all facilitate adaptive innovation in design transformation. By considering, adopting, or transferring multiple identities and cultural meanings between traditional and contemporary societies, this paper goes into further detail about the unique experience of cultural learning and specific approaches that integrate theoretical research and practical experience to promote cultural sustainability.

This study proposes the sustainable cycle of cultural ergonomics, as shown in Figure 5. Five foci are reviewed and summarized based on the previous discussions related to the interactions among vital subjects of user–tool–task, as shown in Figure 11.

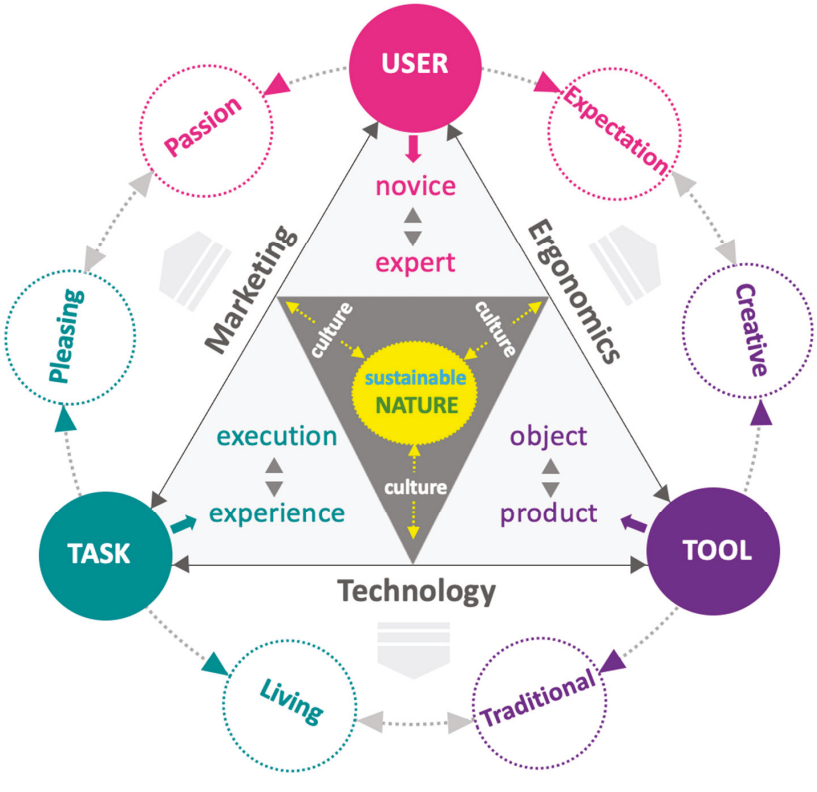

Figure 11. The five foci of cultural education in with ergonomics evolution. (Source: this study).

- From Nature to Culture

Humans are used to learning from nature and developing our culture with the balance of nature. This composes the essential parts of sustainable culture and coheres the humanity's core values.

- From Passion to Expectation

According to the cultural analysis on the outer level, users in the case study may have varied demands, lifestyles, and feelings, with multiple identities in different scenarios. This case study illustrates the humanity of passion and expectation, which echo the user character transfers between novice and expert.

- From Traditional to Creative

On the middle-level, the analysis of function, usability, and behavior related to the tool focuses on transforming it from a cultural object into an innovative product for cultural education. This study explores these possibilities, from traditional to creative.

- From Living to Pleasing

At the inner level, the interaction and experience from ceremony, reflection, and emotion cause the different objectives of task-taking between daily living execution and pleasing cultural experience.

- From Circle to Cycle

The interrelations between the user, tool, and task bring with them advanced ergonomics, technology, and marketing issues. This study employs cultural ergonomics to accomplish product innovation for cultural education. The authors aim to promote cultural evolution from circle to cycle in order to launch education on cultural heritage and its sustainable development.

Integrating our previous study of theoretical references and empirical experiences, the authors suggest an efficient system of cultural ergonomics by employing the analyses of cultural levels and the extraction of cultural features to achieve a balance between technology and humanity [21]. By enhancing our understanding of cultural meaning, cultural ergonomics contributes to contemporary cultural research through improved design implementation and evaluation capabilities [57]. In addition to participating in cultural contexts, developing interactive user experiences is becoming more meaningful and vital in cultural product design [17]. Cultural ergonomics considers and discusses the experience-based variations and interactions among cultures to accomplish cross-cultural product design [31].

This study adopts a methodology-driven project practice that composes methodology-based and project-based advantages [13]. Therefore, this empirical research suggests a much more appropriate qualitative approach than quantitative statistics to evaluate and discuss the potential and paradigm in cultural product innovation for cultural education and sustainable development. One suggestion for future research is to determine how to keep the passion, sensation, and awareness for the declining tribe and community's needs. Another suggestion is dedicated to understanding the traditional culture through residence in that local field for a more extended period to identify and sustain the essential meaning of culture more precisely. Finally, this study suggests enhancing marketing strategies for promoting the cultural products in order to make culturally sustainable development more practicable.

6. Conclusions

Learning from nature used to be the wisdom of aboriginal ancestors. In the past, following natural orientations, different tribal groups formulated the spiritual rituals and created tangible objects belonging to each unique culture. Today, many countries have continued pursuing technological modernization and economic progress. Due to the impacts of global markets and changing fluctuations, facing contemporary challenges by

employing cultural ergonomics to reach the balance between nature and culture, humanity and usability, has become an urgent issue in the design industry and design education.

There are many parallels to these questions and problems everywhere, in that native cultures are disappearing, and their arts and crafts along with them. It is strange that as these cultures diminish or vanish altogether, their old traditional art pieces become more and more sought by museums and private collectors, and consequently become more and more valuable. Beauty is the soul of the artist expressed in her art. Based on strong religious beliefs, tribal arts express that soul very strongly. It is a mystery how tribal arts can speak to someone even across cultural oceans, if not for soul-to-soul communication. As others begin to see the beauty of the art and are moved by it, they wish to possess it, even without understanding or even knowing the culture behind the art; such is the passion of the collector. Such cross-cultural attraction with consequent desire for possession is what designers of products for the international markets should hope to have their products evoke. Continuing studies of what makes tribal arts such as the weavings of the Atayal, or even a "tool" like the weaving box, so attractive cross-culturally can definitely aid in designing successful cross-cultural products. Moreover, these products or learning-aided devices with native cultural meaning can accelerate the foundation of cultural learning through a capable and affordable path and lead toward sustainable development across generations and across cultures.

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Article

A Teaching Model of Cultural and Creative Design Based on the Philosophy of the *Book of Changes*

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Abstract: In essence, cultural and creative design features humanity and culture. The process of how to transform culture into creativity is an essential subject of design education, which, in turn, calls for a new design teaching system. In regard to combining traditional Chinese thinking with modern design experience, the question of how to apply traditional Chinese thinking to design concepts, methods, and education is systematically explored in this research. Firstly, the question of how to transform the philosophy of "Tao, Vessel, Change and Comprehensiveness" in the *Book of Changes* into "design thinking" in order to establish the learning process of creative design with added value—as well as to set up the teaching model of cultural and creative design under "Tao, Vessel, Change and Comprehensiveness"—is discussed. After this, two cases of the Aboriginal Harvest Festival's cultural creativity "Dancing Together" candlestick and the animation, cultural, and creative design of the "Wind Lion God" are used in order to examine the effectiveness of the specific design and to verify the feasibility of this teaching model in the development and application of cultural and creative products. The results demonstrate the feasibility of this teaching model, which provides a new systematic approach for the purposes of teaching and practice in the field of cultural and creative design.

Keywords: Tao; vessel; change and comprehensiveness; design thinking; cultural and creative design; teaching model

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1. Introduction

Due to the fact that the cultural and creative industry has boomed in recent years—and that cultural products have been developed in order to improve the quality of life, and also social and cultural awareness—the practice of design is thus aimed to inherit and maintain culture instead of merely pursuing high technology and nice outlooks [1]. Therefore, the diverse ethnic cultures in the world have been rich resources for the purposes of cultural design, which can, in turn, create value through design. The essence of cultural and creative design lies in humanity and culture, which requires products to be consistent with humanistic aesthetics. At present, the question on how to transform culture into creativity is a critical subject in design education.

Following the advent of the creative economy era, innovative and creative education occupies a central position in the creative economy [2]. Creative thinking comes with design practice and is defined as an analytical and creative process that includes the stages of experiment, model creation, feedback collection, and redesign [3]. Johansson-Sköldberg [4] proposed the concept of design thinking and summarized five categories for this concept, including the creation of artifacts, a reflexive practice, a problem-solving activity, a way of reasoning/making sense of things, and the creation of meaning. Certain scholars advise that design thinking can provide a creative teaching structure for educators,

which is essential for the cultivation of innovative developmental skills [5–7]. Creativity is a peculiar phenomenon that is only possessed, as far as we know, by human beings. The mainstream of modern design is represented by research on creativity, such as creative personality, creative cognition, creative environment, and creative education [8]. Creative thinking capabilities can be developed through effective teaching or training. Some scholars have also explored teaching methods of training students' creativity and systematically described the critical thinking of STEM education, creator education, project-based learning, and inquiry-based learning [9–11]. All of these studies provide a theoretical basis for the teaching model of cultural and creative design in terms of cultural innovation, design thinking, and creativity.

The teaching of cultural and creative design on the mainland is in the infancy stage. As such, it still possesses an immature teaching model, pedagogy, learning theory, and curriculum design [12,13]. Currently, there exists a gap between the curriculum of cultural and creative design in universities and the demand of industry talents. By means of innovating teaching methods, expanding teaching practice, establishing a high-quality faculty training mechanism and a creative mechanism enhancing professional diversion, some studies hope to accomplish an effective connection between university talent training and industrial demand [14]. Some other related research has also discussed the teaching model of combining "Intangible Cultural Heritage" and "Cultural Creation". They explore the path of industry-academy cooperation between culture and applied majors in order to achieve the dual purpose of cultural heritage and artistic creativity cultivation [15]. To integrate creative teaching in universities into local culture, some researchers suggest that it can be achieved through practical activities such as building cultural heritage cultivation mechanism, constructing heritage workshops and industrial studios with cultural characteristics, and conducting cultural thematic courses [16]. Therefore, the research of cultural and creative teaching requires a new perspective and practical manner which extracts typical cultural contents for creative modification. Following that, it can satisfy the needs of technology and humanity, and adapt to the rapidly developing era of knowledge economy [17–19]. Transforming cultural content into cultural product design requires innovation in knowledge structures. It also needs to integrate knowledge and resources driven by ideal human demands and stimulate the creation of new knowledge [20].

In regard to the broad and profound Chinese culture, the *Book of Changes* is a paragon of ancient Chinese philosophy in which the laws of nature and dialectical thought contained within are representative of a crystallization of Chinese wisdom over a period of five thousand years. The core and essence of the *Book of Changes*' design philosophy, "Tao, Vessel, Change and Comprehensiveness", can be applied to design education, which has proved an effective strategy for creative learning [21–24]. Such fine traditional cultural concepts and cultural heritage are significant resources for innovative educational research, which is conducive to solving local problems derived from national practices.

In addition to science, technology, culture, and economy, the development of cultural industry requires culturally innovative design talents. It has been a heated research topic as to how best apply design thinking in order to teach and help students, majoring in design, to represent cultural creativity in their products. Therefore, in this research, the approach on how to transform the philosophy of "Tao, Vessel, Change and Comprehensiveness" in the *Book of Changes* into "design thinking" is investigated. In addition, the learning process of creative design with added value is formed. By exploring relevant design theories, the researchers aim to gradually construct a teaching model of cultural and creative product design. With the design creation practice as a supplement, the researchers also examine the effectiveness of design creation and provide theoretical references for design thinking education. The specific research purposes are as follows: (1) to construct the design thinking of "Tao, Vessel, Change and Comprehensiveness" by recognizing and understanding the relationships among them; (2) to explore how to transform the design thinking of "Tao, Vessel, Change and Comprehensiveness" into a teaching model of cultural and creative

design; and (3) to summarize the teaching procedures of cultural and creative design through guiding design teaching cases.

2. Literature Review

2.1. Construction of the Design Thinking of "Tao, Vessel, Change and Comprehensiveness"

The concept of "Tao, Vessel, Change and Comprehensiveness" derives from Chapter 12 of the Survey, Part I*Xici* of the *Book of Changes*, which states: "the metaphysical realm is called the Tao and the physical realm is called the vessel. The interaction between the two leads to mutual transformation and dissolution of things, which is called change, elaboration, and application of the principles of change are called comprehensiveness. In order to make these principles available for people under heaven to use is called a business".

Indeed, the "Tao" refers to ideas, consciousness, or values, which require the "Vessel" to disseminate; the "Vessel" means a form or artifact, which is communicated though "Tao" and then becomes a symbolic carrier. The philosophy of "Tao, Vessel, Change and Comprehensiveness" is widely adopted in ancient Chinese design. Further, the thought of "the end of any development usually gives rise to changes, changes open ways for development, continuous development can of course last long" provides a concrete way in which to solve the dilemma of design process, management, and education.

The philosophy of "Tao, Vessel, Change and Comprehensiveness" coincides with parts of the Western view of "design thinking", which assumes that the specific manifestation of innovative thinking in design activities encompasses the categories of understanding, observation, conception, creation, and testing [25–28]. The researchers would like to suggest that you do not have to be designers. Instead, you have to be a design thinker. Only with the capacity of design thinking can the concept-driven creative idea be implemented [29]. At this phase, the research focuses on the relationship between "Tao, Vessel, Change and Comprehensiveness" and its deeper intellectual connotations, which contains the interconnection between Tao–Empathy, Vessel–Define, Change–Ideate, Comprehensiveness–Prototype, and Business–Test, as shown in Figure 1.

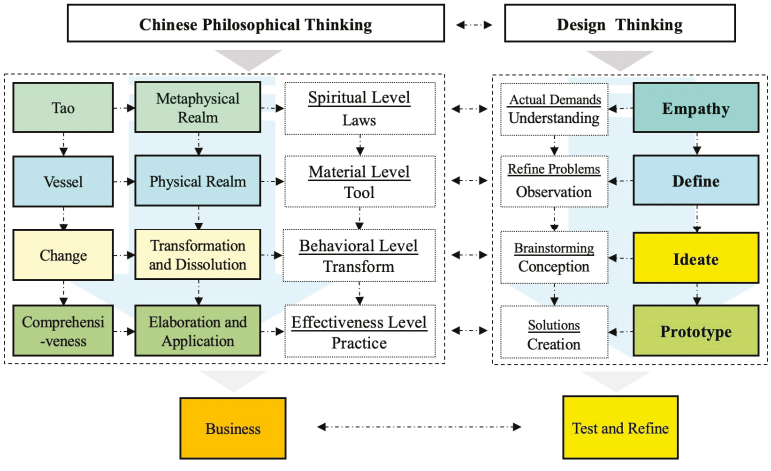


Figure 1. The design thinking of "Tao, Vessel, Change and Comprehensiveness".

First, "Tao" is above the physical and vessel; its essence is the laws and regulations shared by all things in the abstract or spiritual level. Additionally, "Empathy" implies understanding the actual demands of users and their inner thoughts. Both of them originate from the same spiritual experience. Secondly, "Vessel" is below the specified material above and it is a tool commonly used by people. Additionally, "Define" can be interpreted as a specific method to refine the problem via observation and analysis. Thirdly, the "Tao"

and "Vessel" are mutually reduced by the interaction, forming a variation or a change from the behavioral level. Additionally, "Ideate" in design thinking also refers to processes of brainstorming and developing methods in order to solve problems. The two meanings of them are complementary to one another. Fourth, "Comprehensiveness" signifies that the guidelines are turned into general rules, which are applicable to the practice. Additionally, "Prototype" is to make innovations and creations through solutions. Lastly, the philosophy of "Tao, Vessel, Change and Comprehensiveness" may become the core concept in which to guide the related industries, i.e., the creation of the "Business" corresponding to the perfection and realization of design.

Due to the fact that creation or management tends to evolve with the times, the design thinking of "Tao, Vessel, Change and Comprehensiveness" should also be able to break the existing rules and laws, as well as later establish a new paradigm of thinking based on the experience of creation for practical operation and learning [30].

The "Tao, Vessel, Change and Comprehensiveness" analytic can be used to actually think from a human-centered perspective based on "Tao" (the first step). Then, the processes will be presented through the visible and perceptible "Vessel", i.e., using the "Vessel" as the medium including information sharing, integration, concept optimization, and framework building (the second step). Further, the breakthrough of "Change" will be made in the whole creative process, whereby solutions from multiple dimensions are sought, similar to a high-speed coding system (the third step). "Comprehensiveness" refers to the realization of the creation (the fourth step) and the completion of target systems, which constitutes the basis of re-selection, analysis, integration, and re-creation. The entire design thinking of "Tao, Vessel, Change and Comprehensiveness" is a cyclical process which generates creativity and updates knowledge based on repeated iterations of testing and refinement (the fifth step). Therefore, these five elements are intertwined, and on this basis, in this research, the theoretical model construction of "Tao, Vessel, Change and Comprehensiveness" in the context of teaching cultural and creative design will be analyzed.

2.2. Theoretical Framework for the Teaching of Cultural Creativity and Design with Added Value

In Western models of creativity, MIT—for instance—divide the purpose of education into three levels, namely reason, knowledge, and wisdom, which are embodied in the teaching [31]. The strategic management ideologist Roger [32] considered that knowledge creation in humans consists of three stages: exploring the puzzle, gaining insight, and forming patterns, which are collectively called the "Knowledge Funnel". Regarding inference-level teaching, it is supposed to help develop pure critical and reasoning abilities in a bid to flexibly use scientific tools and investigation methods. This teaching method can be regarded as collecting, evaluating, and using relevant information in order to solve complex puzzles and to explore unknown mysteries. In cultural and creative teaching, the inference-level teaching method is manifested in the transformation of raw cultural data into useful design information through analysis and comprehensive coding. This is such that the data can be endowed with meaning, i.e., "Added Value Through Information". In terms of the knowledge-level teaching approach, it should be to cultivate systematic application capabilities and to discover the essential laws of information on the basis of comparison and analysis, as well as to gain conceptual insight. This is expressed in the approach of cultural and creative teaching serving as the further understanding and generalization of information into knowledge, i.e., the "Added Value Through Knowledge". Regarding intelligence-level teaching, it should be to develop students' patterned structure of knowledge that allows them to use intellectual strategies rationally in order to solve problems and thus ponder topics relevant to science, ethics, and art. In cultural and creative teaching, it is presented as the flexible application of knowledge to design and production through creative courses, thus sublimating creative cognition. Therefore, each knowledge point can be arranged as such in order to build a structured mental model of the knowledge elements, which is the formulation of "intelligent property". Additionally, it must also

be noted that this stage is called "Added Value Through Creative". These processes may all be considered the double diamond design process model, in which data, information, knowledge, and intelligence continuously "diverge and converge" [33].

The teaching procedure of cultural and creative design is divided into two aspects in this research: basic research and applied research [34]. Basic research illustrates the structuring of creative data (diverge), while applied research practices the structuring of answers: which is to transform solving problems with knowledge into a law (converge) [35]. For this reason, the abovementioned also echo the design thinking of "Tao, Vessel, Change and Comprehensiveness". In terms of design practice, the "metaphysical realm" refers to the abstract process. Here, the intangible but regular connotation of thoughts, which reflects wisdom and demonstrate the soft power of culture, is extracted. The "physical realm" generally denotes specific inquiries—which is a technical guideline after the summary of the creative results—and presents tangible and communicable masterly skills. Certain scholars have managed to propose solutions to the relationship between the cultural product design process, the cultural and creative design value-added process, and the cultural and creative teaching process [2,36]. In order to achieve this, they constructed a theoretical model of teaching cultural and creative design, as shown in Figure 2.

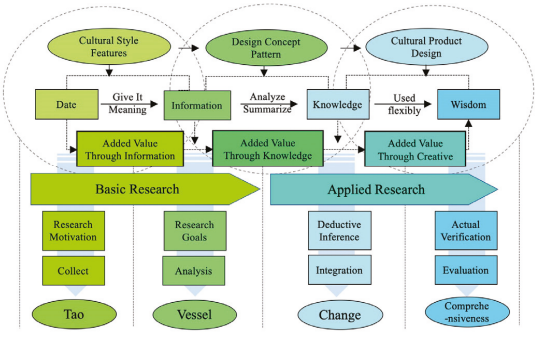


Figure 2. Theoretical framework for teaching of cultural creativity and design with added value.

2.3. The Scenario Approach of Cultural and Creative Design

The scenario approach is a design method that is utilized in order to create a product usage scenario through an imaginary story in the development process of a product [26]. Its main purpose is to connect the relationship between user characteristics, events, products, and the environment, as well as to describe future usage scenarios through imagination in order to explore product visions and design themes. The purpose of design is not only to make it convenient for consumers to use, but also to find the best product position and levels of consumer recognition, which are the hallmarks of good design. An excellent cultural design can trigger emotional requirements and cultural introspection within consumers. Therefore, the scenario approach seeks to create a possible scenario based on the attributes, features, and connotations of a product from the designer's standpoint of the user. It prompts users to create an empathetic effect during the operation of the product and to establish an imaginary space and atmosphere mentally, thereby finally allowing them to be immersed in the scenario [37–40].

The scenario approach incorporates the concept of product semantics and constructs the reference relationship between cultural symbols and products through rhetorical means. It emphasizes the communication between products and users and conveys the connotation and meaning of cultural symbols. Product semantics defines the product as a symbolic system, examining the symbolic qualities of the product form in the context of operation and utilization [41]. The metaphorical and symbolic logic is integrated into the product design, which is more flexible and innovative in terms of transmitting religious beliefs, historical customs, national emotions, regional characteristics, mythological stories, and

other cultural connotations. This means there is a focus on the conveying of the inner meaning and emotional depth of the product through its shape and usage. The commonly used metaphorical design devices include metaphor, simile, metonymy, analogy, and allegory, which subtly transform the visual association between products and symbols [42]. This is an interpretative manner of product communication and transmission.

The process of an IDEO application in regard to a scenario approach to innovative product design can be divided into five steps: understand, observe, visualize, evaluate and refine, and implement [43]. Certain scholars have further classified the implementation procedure of the scenario approach into four stages: set a scenario, tell a story, write a script, and design a product. They have attempted to apply the scenario approach to cultural and creative design in order to verify the possibility of the approach through the rich storytelling of culture [44]. The stage of setting a scenario requires designers to make records of people, events, times, places, and substances based on their past life experiences, set them in the context for the future use of the design product, and conduct time-to-space conversion of the design use context in a descriptive metaphorical way. The stage of telling a story situates the design within an empathetic default theme, telling a story through imagination in an intertwined time and space setting. In this phase, the hypothetical scenarios and usage of the future product to be developed are gradually portrayed, and the design elements can be used to transform into materials for deeper imagination. The stage of writing a script passes through the written script description and key words of design elements, including cultural connotation, usage, operation method, usage situation, behavior pattern, etc. This concept makes further conceptual deduction and interpretation through simile, metonymy, analogy, etc., for more reasonable and logical subsequent design development. The stage of designing a product has already generated the prototype of the product ready for planning. Entering the preliminary drawing stage of product design, the product's stereo-model design is subsequently completed via software, which also integrates modern 3D printing and traditional machining principles and operational practices. The design in each phase of the scenario approach resembles the design practice led by the design thinking of "Tao, Vessel, Change and Comprehensiveness", as shown in Figure 3. The scenario approach helps to provide a practical direction for design through a simulated contextual analysis, helps to implement relevant operational highlights, and lays out orderly steps for the purposes of achieving design goals.

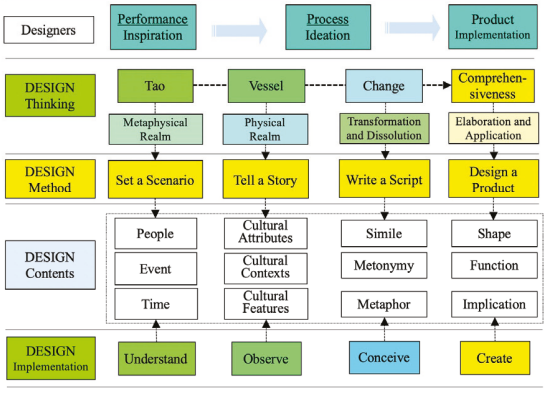


Figure 3. The scenario approach of cultural and creative design.

3. Methodology

3.1. Conceptual Framework of the Teaching Model

The essence of cultural and creative design is a complex coding system. The manner of coding not only determines the establishment of the knowledge structure, but also deduces

new information and migration, which indicates the formation of creative behavior. When a person's coding system is endowed with certain information, it will be created through learning and application. From basic theory to application practice, it also means the enhancement of a personal competence from concept to practice. The process of application practice to final innovation development is one process of using knowledge strategy in order to realize knowledge creation, which is a series of spiral escalations of innovation-based teaching processes. Based on the above research explorations, in this research, several models from the literature review are combined and a teaching model of cultural and creative design under the design thinking of "Tao, Vessel, Change and Comprehensiveness" (Figure 4) was established.

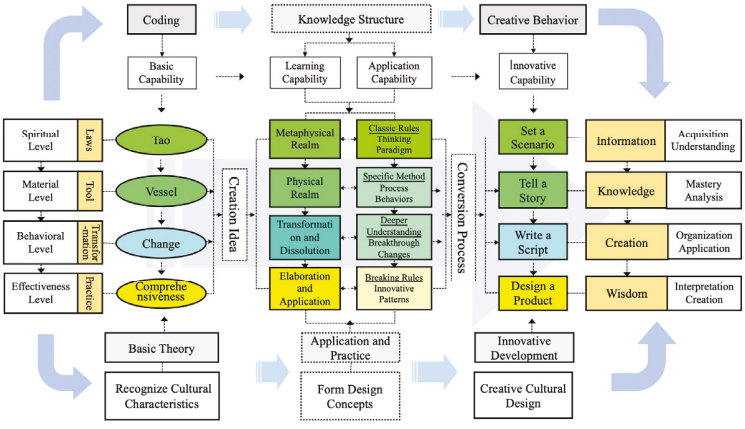


Figure 4. Conceptual framework of the teaching model.

Firstly, at the basic theory level, the essence of the research on constructing the code of "Tao, Vessel, Change and Comprehensiveness" is a coding principle consisting of laws at the spiritual level, tools at the material level, transformation at the behavioral level, and practices at the effect level, which all provide the writing of creative concepts with a logical scope. As a universal law, the "Tao" is the guiding principle of the whole cultural and creative design, including the discussion of the design consensus and the understanding of cultural products. The "Vessel" is a perceptible tool, consisting of the steps of establishing the target group, describing the usage context, and establishing the design plan. The "Change" is the result of the transformation, including the steps of analyzing cultural characteristics, linking product lines, and selecting appropriate concepts. "Comprehensiveness", as the result of design coding, includes two stages of design development and finalization.

Secondly, the acquisition and utilization of knowledge are determined by learning and application capabilities. The philosophy of "Tao, Vessel, Change and Comprehensiveness" is developed into the realization of specific capacities at the application and practice level. The "Tao" transforms into the guidance of the "classical rules and thinking paradigm", the "Vessel" into the outcome of the "specific method and process behaviors", the "Change" into the effect of the "deeper understanding and breakthrough changes", and the "Comprehensiveness" transforms into the result of the "breaking rules and innovative patterns".

Thirdly, the development of innovative ability that is reached by the transformation of the scenario approach consists of four stages. First, "Set a Scenario" is the acquisition and comprehension of information; second, "Tell a Story" is the mastery and analysis of knowledge; third, "Write a script" is the organization and application of ideas; fourth, "Design a product" is the interpretation and creation of wisdom.

Therefore, the whole system exemplifies the innovative learning process from the recognition of cultural characteristics and the formation of design concepts to creative and cultural design, which deserve to be explored through case studies.

3.2. Overview of the Case

This research adopts a case study approach in order to explore and verify the feasibility of applying this teaching model to the development of cultural and creative products. The "feasibility" mentioned in this research refers to whether the proposed teaching model can be used to guide the implementation and practice of creative practice. Its measurement criteria are whether the four stages of design planning, namely "Tao, Vessel, Change and Comprehensiveness", are carried out smoothly, and whether the design concept can be finally transformed into a design product with cultural characteristics, values, and meanings. In the process of designing cultural and creative products, seeking a reasonable transformation of cultural characteristics and product presentation is a complex process. A case study approach to validate this teaching model contributes to examining the rationality of the design process and the consideration of the development of cultural products at various levels, hence designing products with cultural connotations.

In this research, two study cases of the Aboriginal Harvest Festival's cultural creativity "Dancing Together" candlestick and the animation, cultural, and creative design of the "Wind Lion God" as examples are utilized in order to examine the effectiveness of applying the model to specific design processes. In this research, two aspects of Aboriginal culture in Taiwan and Chinese mythology as the starting point to explore the possibility of cultural transformation into creativity and specific implementation steps is employed, as shown in Figure 5. Based on the core thinking of "Tao, Vessel, Change and Comprehensiveness", this phase of research uses relevant design methods to transform the cultural contents and gradually complete the design of cultural and creative products. First of all, Aboriginal culture has unique cultural features which can offer abundant creative resources for the purposes of design conception. It is also able to help shape construction and to stimulate the formation of creative imagination. The "Dancing Together" candlestick transforms the nostalgia for the past of Taiwan's Harvest Festival into a modern living situation through the creative learning method of "Tao, Vessel, Change and Comprehensiveness", and demonstrates the richness of Aboriginal culture through cultural and creative products. The analysis starts from the four directions of Tao, Vessel, Change and Comprehensiveness, which captures the characteristics of the scenario approach. The stage of Tao and Vessel refers to the conceptual formulation, while the stage of Change and Comprehensiveness refers to the design transformation of the concept. Secondly, Chinese mythology is the essence of Chinese civilization and the crystallization of national wisdom, which provides a wide space for creative design. The "Wind Lion God" designs an animation character by combining myths and legends through the teaching model of "Tao, Vessel, Change and Comprehensiveness". The stage of Tao and Vessel refers to systematically analyzing cultural data and extracting its attributes, which is the stage of design conceptual formulation, while the stage of Change and Comprehensiveness refers to transforming the design vein and then realizing character design. Both cases use the same framework and design process of "Tao, Vessel, Change and Comprehensiveness". Among them, the case of "Wind Lion God" focuses more on the application and description of the scenario approach, as this approach can clearly present the transformation process of cultural creativity after four stages of research and development. The scenario approach inherits cultural assets and characteristics through the design process, and presents a multifaceted design interpretation process under the framework of "Tao, Vessel, Change and Comprehensiveness", which is more suitable for the extraction and transformation of cultural elements in mythology. Consequently, taking these two examples as research objects not only profoundly analyzes the creative transformation of different cultures, but also helps to argue for the diversity of cultural and creative design applications. Two such cases have typicality and research value; further, they are suitable for the purposes of validating this research model.

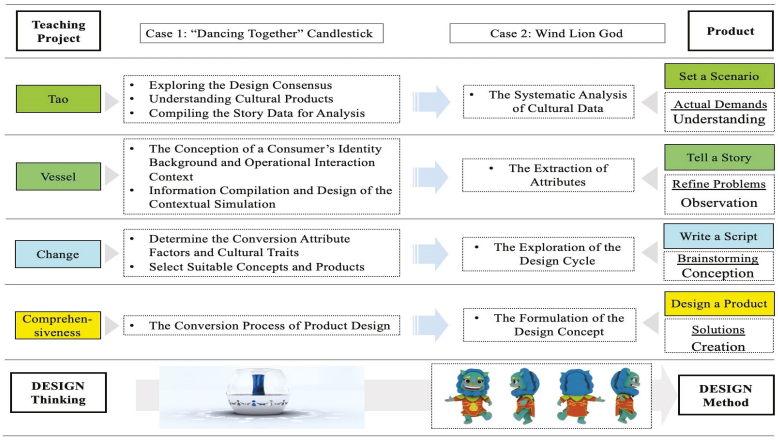


Figure 5. The process of transition from design thinking to design method.

4. Case Analysis and Discussion

4.1. The Aboriginal Harvest Festival's Cultural Creativity "Dancing Together" Candlestick

4.1.1. Design Concept of the "Dancing Together" Candlestick

This phase adopts the Aboriginal Harvest Festival's cultural creativity "Dancing Together" candlestick, which was designed by the creative team of the School of Design, National Taiwan University of Arts, as a case study, as shown in Figure 6. In this context, researchers conducted a study on the teaching of cultural and creative design, based on the design thinking of "Tao, Vessel, Change and Comprehensiveness". This study has been authorized by the creative design team in order to display the design results and to analyze the design process. Thus, in this study, we are seeking ways to transform the nostalgia for the past of Taiwan's Harvest Festival into a modern living situation through the creative learning method of "Tao, Vessel, Change and Comprehensiveness". Additionally, this is also achieved by using cultural and creative products to show the richness of Aboriginal culture, as well as to enrich cultural and creative products with culture. These are the topics explored in this phase. Cohesion is the theme of the "Dancing Together" candlestick. Moreover, it subtly applies the scene of the Aboriginal people celebrating around the fire during the ceremony to the candlestick. As the candlelight sways with the air, it is as if the crowd is holding hands in a circle, dancing with the wind in celebration. The candlestick recreates the Aboriginal people's prayers for hope and reverence for their ancestors, as well as to the heavens through the value-added design of cultural creativity, which reveals the depth of cultural connotation and the aesthetics of life.

Figure 6. The Aboriginal Harvest Festival's cultural creativity "Dancing Together" candlestick. (Source: the product shown in figure was designed by the creative team of the School of Design, National Taiwan University of Arts, which has allowed this article to use their product).

4.1.2. Design Hierarchy of Emotional Experience for the "Dancing Together" Candlestick

The design concept of the "Dancing Together" candlestick takes the Aboriginal story as the model. The main requirements of the design are experience and memory, which aims to aid in allowing users to rediscover the touching moments from this culture at diverse levels. In terms of communication theory, they argue that successful coding by designers needs to satisfy three levels, namely the technical level, the semantic level, and the effect level [45–47]. The users' emotional experience of an artistic work involves their decoding process. At the level of the body's instinct, the users will be attracted by the external senses of an artistic work; at the level of the mind's behavior, they will understand and feel the meaning beyond the perception of artistic works. Eventually, they will return to the level of spiritual reflection where the audience will be touched deeply in their hearts, and the artistic work will be evocative of their memories of emotion in their lives [48,49]. The candlestick is composed of four layers of meaning, which creates a context through its lighting function and forms an emotional communication between the user and the product. The first and second layers are the physical characteristics of the product. The first layer is dominated by a glass cover with a lighted lamp post in the middle. It is surrounded by embossed, hand-holding imaginary human figures that express the overall scene of Aboriginal festivals and celebrations. The second layer is composed of a hollowed-out outer plate with a variety of materials featuring hollowed-out human figures that are used in order to convey visualized affection. The third layer exhibits the functional aspect of the candlestick, with a reflection of the light of human figures. The desktop is illuminated by the candle flame, revealing the light and shadow of human figures. As the flame shakes it seems to be dancing lightly, which is similar to the Aboriginal celebration of the Harvest Festival with a heartwarming atmosphere. The fourth layer reflects the spiritual aspect of the product, i.e., emotional cohesion. When a family sits around dinner, the "Dancing Together" candlestick is similar to building a bridge of affection, in which people experience the passionate atmosphere and cohesively care for each other in their hearts.

4.1.3. Design Procedures for Creative Design of the "Dancing Together" Candlestick

1. Design procedure of the "Tao" stage

In this research, the design thinking of "Tao, Vessel, Change and Comprehensiveness" to lead the formation, development, and execution of the creative idea of the "Dancing Together" candlestick was adopted. The first stage is "Tao", which is specifically the setting scenario. Further, it is divided into three steps: exploring design consensus, understanding cultural product, and compiling story data for analysis.

On the topic of exploring design consensus phase: this stage is to collect and analyze cultural data, as well as to understand and reflect on it with the purpose of obtaining the background content of the Harvest Festival and, thus, exploring its core spirit [1]. The core spirit of the story is fourfold: promote "faith and emotion among the community" through "an atmosphere of celebration and recreation"; achieve "a symbol of thanksgiving and blessing"; and achieve a ritual of "the effect of holding hands around the campfire", as shown in Figure 7.

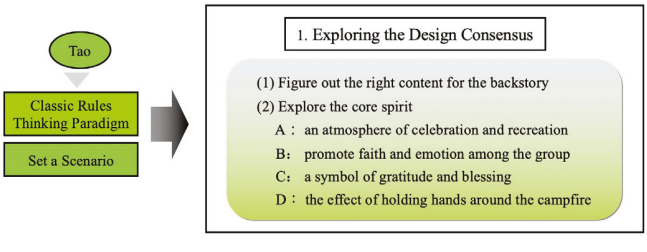


Figure 7. Exploring the design consensus.

In regard to understanding cultural product phase, this stage refers to the analysis of the connotations of cultural levels, i.e., the process of deepening data further into information. Cultural space is distinguished into three levels, i.e., physical (outer-level), behavioral (mid-level), and psychological (inner-level) [29,50]. The visible physical level includes the campfire, the Aboriginal people circling, and the multi-layered effect; the intermediate behavioral level comprises hand-holding and joyful dancing; the psychological level consists of showing an atmosphere of celebration and recreation, thereby promoting the group beliefs and cultural rituals that symbolize gratitude and blessing, as shown in Figure 8.

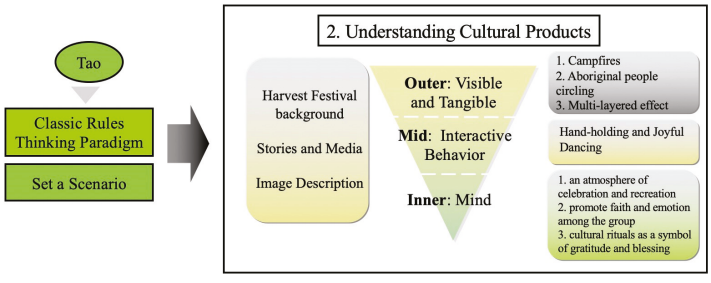


Figure 8. Understanding the cultural product.

Regarding compiling the story data for analysis phase: this stage is a way to use information to add value. First, the researchers should organize and analyze the data of cultural stories systematically. Then, the original stories should be grouped into relevant information. Lastly, the researchers should analyze each of these stories according to the attributes as per the three levels of culture, and consider the suitable genre for the envisioned product [51]. The design connotation contains ethnic group, title, genre, image code, material use, color structure, shape characteristics, operation usage, pattern type, shape constitution, composition form, deeper meaning, cultural significance, and story context [44], as well as exploring the attribute vocabulary, commodity context, and category of the designed goods, as shown in Figure 9.

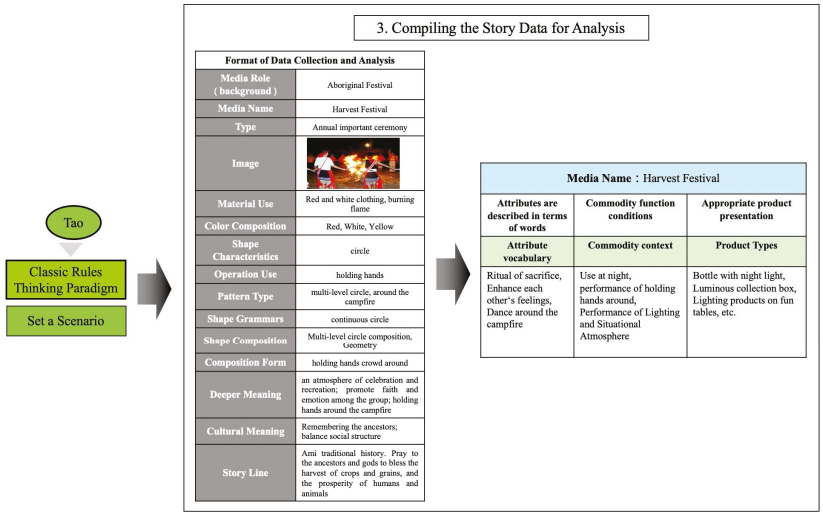


Figure 9. Compiling the story data for analysis.

2. Design procedure of the "Vessel" stage

The second stage is "Vessel", specifically the process of telling the story, which is an approach of using knowledge to add value. It is separated into two steps: first, conceive the consumers' identity background and operational interaction context; second, compile the information of the contextual simulation and design solutions.

In regard to conceiving the consumers' identity background and operational interaction context phase, this stage is based on the above design attributes and product requirements; moreover. In this stage, the characteristics of consumers who purchase such cultural and creative products from the viewpoints of the economy, social environment, and technological development are set [52]. The economic level helps to determine the life proposition, taste, and shape of the target customers; the social environment level aids in defining the target customers' comprehension and empathy for cultural meaning and stories; the technological development level helps with deciding the target customers' choice of product types and characteristics [53,54]. Secondly, the interaction situation between the target customers and the product in life is envisioned in this stage, mainly in regard to involving people, events, time, place, things, and usage. Additionally, its purpose is allowing designers to understand the background qualities and usage of the consumers when corresponding with the cultural and creative products, as shown in Figure 10.

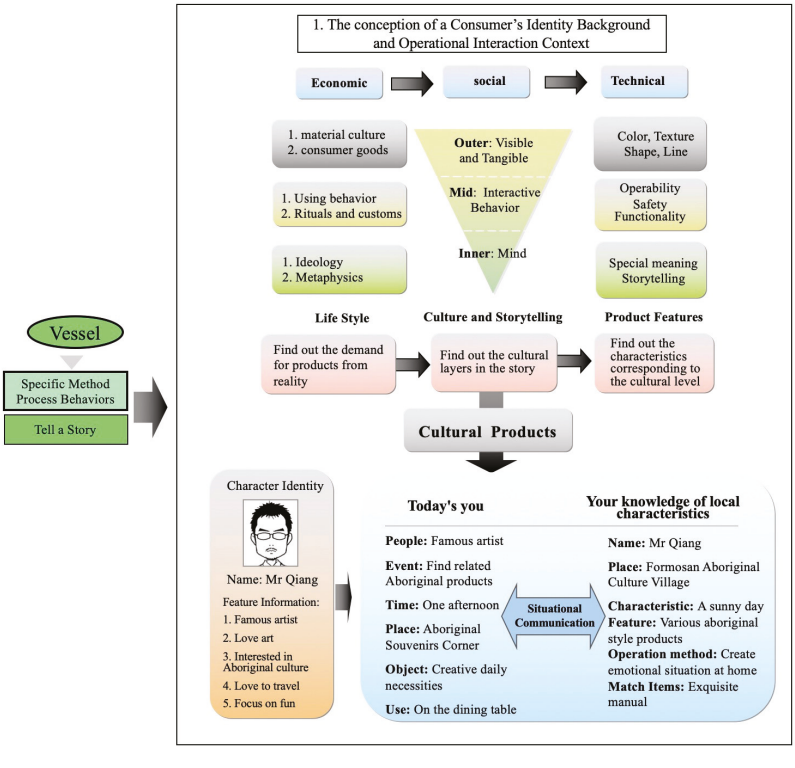


Figure 10. The conception of a consumer's identity background and operational interaction context.

Regarding the compile information of the contextual simulation and design solutions phase, this stage means converting the contextual information into the design requirements of the product. The researchers should compile the simulated information in the form of life and start from the products' image requirements, application characteristics, and functional guidelines in order to design the cultural product [55,56]. In regard to the

economic level, this stage helps with exploring the image requirements in life patterns, which can be storytelling, sensual, pretty, pleasant, and a moody or moving atmosphere. In regard to the social level, the notion on how to reflect on the culture of life and contextual stories in order to demonstrate the application characteristics of its goods, such as daily necessities, decorative effects, and contextual lighting, should be investigated. In regard to the technological level, the possibility of the shape, skill, and meaning of the product, as well as identifying the functionalities corresponding to the cultural level (such as assembly effects, applicable situations, and usage methods), is considered, as shown in Figure 11.

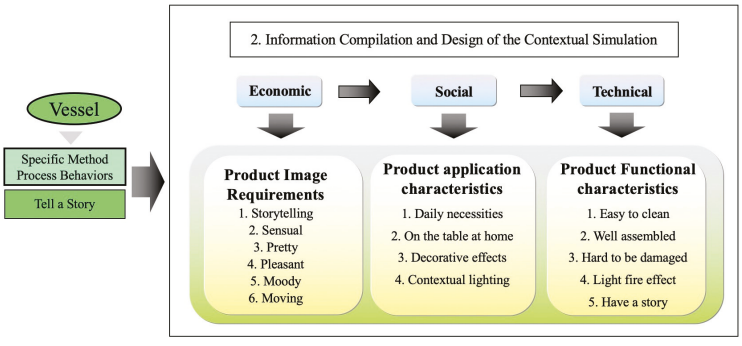


Figure 11. Information compilation and design of the contextual simulation.

3. Design procedure of the "Change" stage

The third stage is "Change", which is understood to be specifically writing a script. This is the process of using creativity in order to add value. It is divided into two phases: first, when the conversion attribute factors and cultural traits are determined; second, when selecting suitable concepts and products.

In regard to determining the conversion attribute factors and cultural traits phase, this stage is mainly for the purposes of determining the cultural traits, commodity context, and product category depending on the guidelines [57]. First, in this stage, the cultural traits from the story, such as the celebration and recreational atmosphere; the promotion of a sense of collective belief and emotion; the symbol of thanksgiving and blessing, as well as the harmonious scene of holding hands around the fire, are all summarized. Then, there is some correspondence to the context of product attributes, e.g., the campfire corresponds to the thinking of a dim environment, people holding hands corresponds to the harmonious atmosphere of thanksgiving and blessing, and lighting corresponds to the presentation of the situation. Finally, with regard to the type of goods, the researchers envision style goods, lighting effects, or special atmosphere in this stage, as shown in Figure 12.

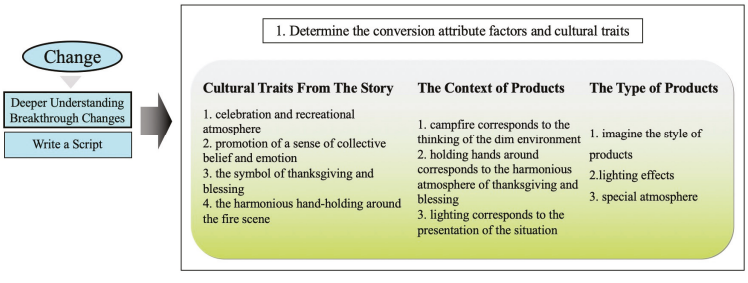


Figure 12. Determining the conversion attribute factors and cultural traits.

Regarding the select suitable concepts and products phase, the type of products that meet these attributes and characteristics are conceived based on the three aspects of cultural traits, product context, and product genre, as mentioned above. By conducting this, ideas are combined with diversity. For instance, the properties of luminous lights are playfulness, environmental embellishment, night glow, context creation, etc. Another example is that the properties of luminous collection boxes have the effect of representing identity symbols, high artistic value, creative modeling, and display effects. Again, for example, the commodity imagery of interesting table lighting products includes irregular graphics, the effect of holding hands, and human-shaped flashing lights, which can enhance the emotional atmosphere, as shown in Figure 13.

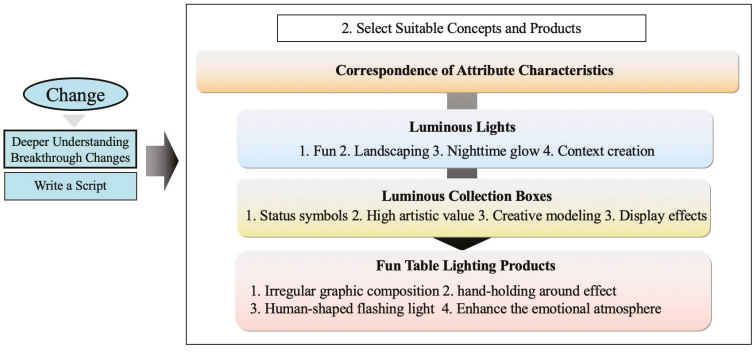


Figure 13. Select suitable concepts and products.

4. Design procedure of the "Comprehensiveness" stage

The fourth stage refers to "Comprehensiveness", i.e., specifically designing the product, which is the process of using wisdom to add value. It is composed of two steps: first, convert the attribute elements into the selected existing products; second, the conversion process of the product design.

Regarding the convert attribute elements into selected existing products phase, in this stage, based on the above envisioned products and the attribute factors to be converted, the researchers should find the most suitable type of product. After compilation, this phase will select the circular surround, hand-holding dance ceremony, campfire lighting effect, and the display of enthusiasm and vitality as the elements of the whole story conversion.

Regarding the conversion process of product design phase, this step is to correspond the selected product categories and conversion attribute elements together to the three levels of culture [29]. After sorting these, the ultimate design sketch is formulated. The products related to interesting table lighting are chosen. The imagery characteristics of the merchandise include geometric circular composition, the holding hands effect, the flickering of the human-shaped lights, and the promotion of the emotions and topics among friends and relatives at dinner, etc. Additionally, the transformation elements of the story theme consist of a circular surrounding, holding hands and dancing rituals, campfire lighting effects, and the display of enthusiasm and vitality. These correspond to the three levels of cultural attributes, namely the tangible and visible external levels, the interactive behavioral intermediate level, and the invisible spiritual internal level, as shown in Figure 14.

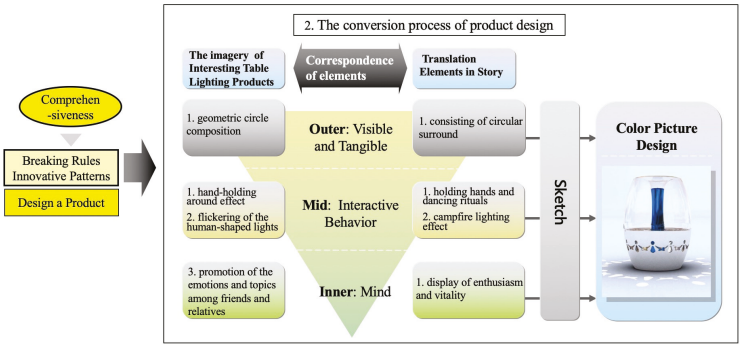


Figure 14. The conversion process of product design.

5. Design procedure of the "Business" stage

The fifth stage is "Business", specifically the design assessment step. The results of this stage influence the industrial design and consumer orientation. In this step, the design reflection, optimized product, illustration of the iteration, and renewal of the product are conducted. Moreover, the researchers should select and integrate semantically feasible specific shapes. For the purposes of future development and production, the researchers should also focus on the feasibility of production and technology when evaluating design to examine the maturity and rationality of the design concept through evaluation. In this way, the product is evaluated based on two criteria, which are the expectations of product design that consumers emphasize when purchasing cultural and creative products, as well as the standard of general products in design competitions [58,59]. The purpose of these practices is to achieve design reflection, as shown in Figure 15.

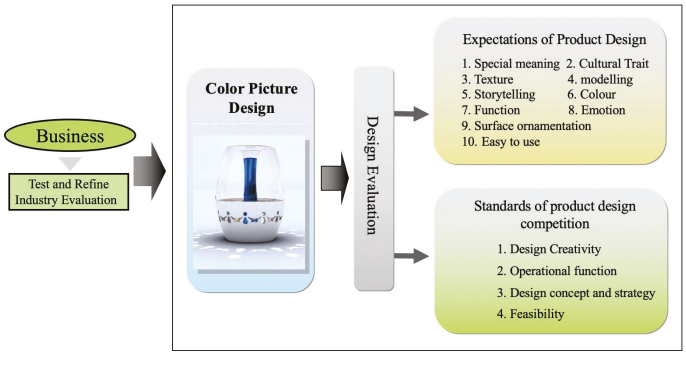


Figure 15. Evaluation and design stage.

4.2. Animation, Cultural, and Creative Design of the "Wind Lion God"

The main purpose of this phase of research is to combine mythology and legends in order to transform the classic mythological images into animation-based cultural and creative works. These transformations should possess new vitality and artistic value through the creative design teaching under the design thinking of "Tao, Vessel, Change and Comprehensiveness". We took the mythical character "Wind Lion God" as the research object and conducted the design research in four steps: from the systematic analysis of cultural data to the extraction of attributes, to the exploration of the design cycle, and finally to the formulation of the design concept. As such, a process encompassing how to extract cultural elements, turning them into cultural symbols, and presenting the product shape was completed [41,60].

4.2.1. "Tao"—Set a Scenario

At the beginning of the discussion regarding design objectives, students and faculty jointly discussed and clarified the positioning of the cultural product, and formulated the emphasis of initial design requirements. A questionnaire survey was set up to investigate the cultural characteristics and product types of this mythological image. From the survey results, the researchers learned that this content in regards to special connotations, cultural traits, texture, shape, storytelling, color, and other factors, is an important attribute for the audience to appreciate animation-based cultural and creative design.

Subsequently, the researchers explored the presentation of the attributes of product culture from the level of cultural space [29,61]. First, the researchers understood and analyzed the context of the mythology of the "Wind Lion God" from the literal level and inspected it from its sources in the ancient literature. Secondly, the researchers further analyzed and summarized the deeper special implications of the myth of the "Wind Lion God" from the meaning level. Thirdly, the researchers extracted and summarized the core mythological features of the incarnation of the "Wind Lion God", i.e., the mythological warrior Chiyou from the intangible level. Its features include the brave and warlike image, as well as the mythological function of exorcising evil spirits, as shown in Figure 16.

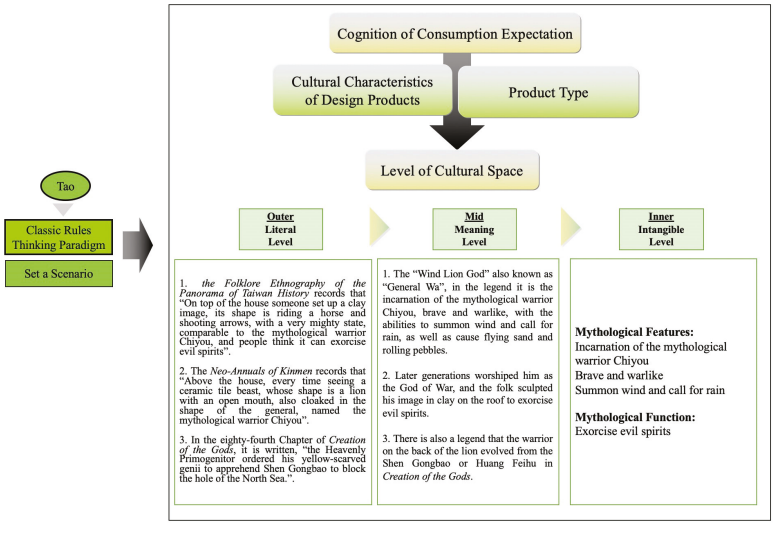
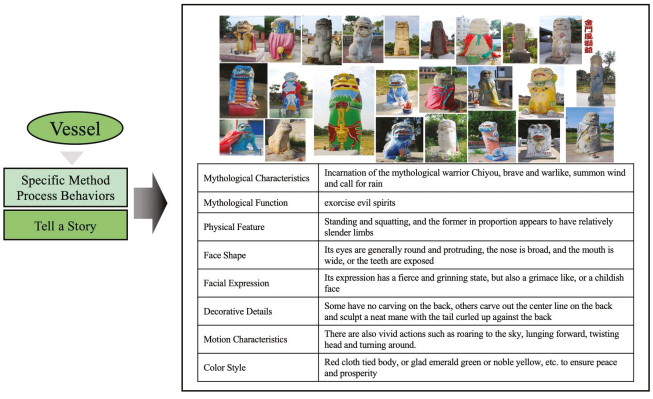


Figure 16. "Tao"—set a scenario.

4.2.2. "Vessel"—Tell a Story

In combining the textual data analyzed above, within this stage the picture data of the "Wind Lion God", which was collected from various places such as southern Fujian, eastern Guangdong, Anping, Taiwan, and the Ryukyu Islands, was classified and sorted. The basic features of the Wind Lion God are outlined in terms of mythological characteristics, mythological function, physical features, face shape, facial expression, decorative details, and color style, as shown in Figure 17.

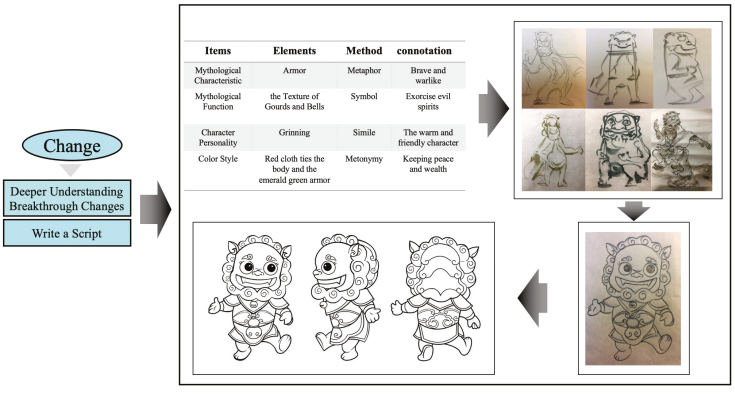


Mythological Characteristics	Incarnation of the mythological warrior Chiyou, brave and warlike, summon wind and call for rain
Mythological Function	exorcise evil spirits
Physical Feature	Standing and squatting, and the former in proportion appears to have relatively slender limbs
Face Shape	Its eyes are generally round and protruding, the nose is broad, and the mouth is wide, or the teeth are exposed
Facial Expression	Its expression has a fierce and grinning state, but also a grimace like, or a childish face
Decorative Details	Some have no carving on the back, others carve out the center line on the back and sculpt a neat mane with the tail curled up against the back
Motion Characteristics	There are also vivid actions such as roaring to the sky, lunging forward, twisting head and turning around.
Color Style	Red cloth tied body, or glad emerald green or noble yellow, etc. to ensure peace and prosperity

Figure 17. "Vessel"—tell a story.

4.2.3. "Change"—Write a Script

In this phase, exploring the style and shape of the "Wind Lion God" design and incorporating attributes such as color, texture, structure, surface ornamentation, detailing, composition, structural relationships, special implications, storytelling, character personality, cultural traits, functionality into the design, and drawing creative drafts were all developed [60]. Moreover, in this stage, consideration to product semantics and corresponding the attributes to the character characteristics context individually through creative devices, in the design, such as metaphor, simile, and symbol, was conducted [42]. Finally, we formed creative ideas from the analysis of many cultural features, complete concept sketches, and found a better conversion context to meet the initial audience appreciation requirements [62]. For instance, at the level of the mythological characteristics, the armor implies brave and warlike traits; at the level of the mythological function, the texture of gourds and bells on the clothes connote its function of exorcising evil spirits; at the level of character personality, the grinning reveals the warm and friendly character, but the hard teeth on both sides imply the mighty and fierce aspect of the mythological warrior Chiyou; at the level of color style, the red cloth ties the body and the emerald green armor reflects the character's function of keeping peace and wealth, as shown in Figure 18.



Items	Elements	Method	connotation
Mythological Characteristic	Armor	Metaphor	Brave and warlike
Mythological Function	the Texture of Gourds and Bells	Symbol	Exorcise evil spirits
Character Personality	Grinning	Simile	The warm and friendly character
Color Style	Red cloth ties the body and the emerald green armor	Metonymy	Keeping peace and wealth

Figure 18. "Change"—write a script.

4.2.4. "Comprehensiveness"—Design a Product

This phase is mainly for designing products, thinking about design conversion and design presentation. It is a process through which the design concept is visualized through

text and draft descriptions, as shown in Figure 19. Before the design is finalized, the researchers explore new possibilities of the product based on the conversion of design thinking, as well as the diversified handling of angle, style, and detail [63]. Further, the researchers use modern technology in order to model and render the "Wind Lion God". In this process, the researchers make diversified attempts, such as single-line flat painting, vector style, ink style, and other abstract processing, which brings cultural vitality into the product. Finally, in this case, the image of the "Wind Lion God" was selected. It was dressed in red–green armor, with a grinning face. This was in addition to the design possessing cloud stripes, gourds, bells, and other accessory elements. These characteristics of the design entail that the role of the product is flexible and versatile, brave and warlike. Its open mouth implies the function of summoning wind and the calling for rain. Further, its traditional pattern elements comply with the characteristics of the Chinese art modeling. These endow the viewer with the aesthetic experience of Chinese aesthetics. The research finally takes three-dimensional shape in presenting the role of the "Wind Lion God", thereby providing new possibilities for the subsequent development of product functionality.

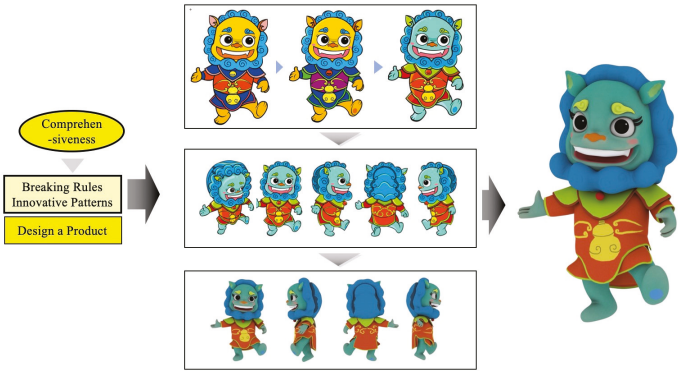


Figure 19. "Comprehensiveness"—design a product (Source: the product shown in figure was designed by Wen-Ting, Fang and Rui-Min, Yang; drawn for this study).

5. Conclusions

As the core of this research, the teaching model of cultural and creative design under "Tao, Vessel, Change and Comprehensiveness" illustrates the implementation of the design teaching procedure. This model starts from the four steps of "Tao, Vessel, Change and Comprehensiveness" and completes the integration of teaching cultural and creative design to the industry through teaching methods, which includes presentation, discovery, practice, reinforcement, and reflection, as shown in Figure 20. With the above practices and exercises, the feasibility of this design process is discussed.

First, the phase of "Tao" aims at sorting cultural data into information, discussing design consensus, understanding cultural products, and reflecting on the design requirements. Specifically, at the beginning of the design process, the researchers understand the real needs of the target product and focus on the generalization of cultural characteristics. At the same time, the researchers envision the cultural attributes suitable for conversion into product design, inspect the genre of products with cultural characteristics, and focus on cultural product requirements in terms of form, function, and spirit.

Secondly, the stage of "Vessel" focuses on analyzing and summarizing information in order to form knowledge. It regards three aspects as the teaching content. These are formulating target groups, describing usage situations, and establishing the design specifications. Specifically, this stage is regarding the extraction of core issues during the design process. The process starts from the analysis of cultural characteristics and the description of cultural attributes. Next, the categories and context of the designed product

are explored, as well as the characteristics that may be developed in the semantics of the product. Then, the cultural attributes and characteristics in the form of list are also explored.

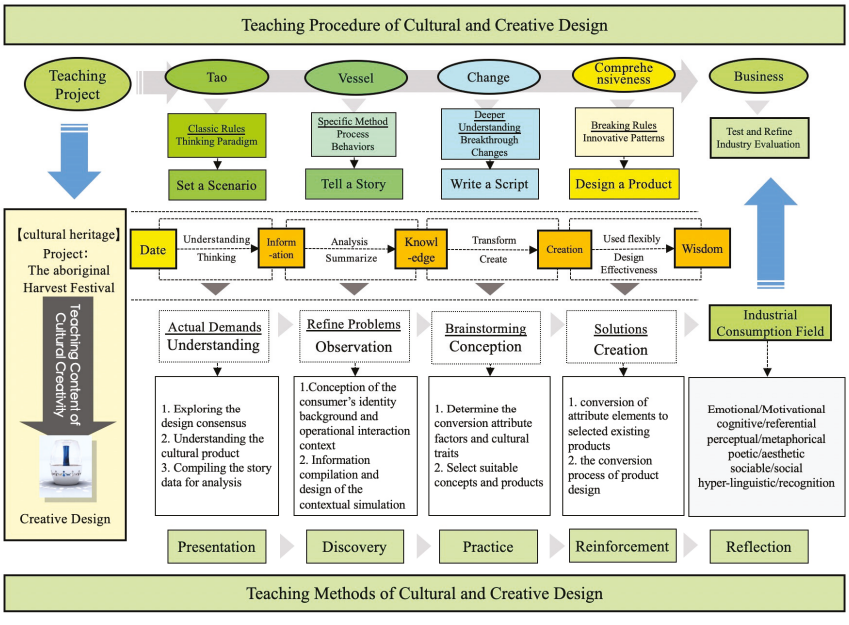


Figure 20. The teaching procedure of cultural and creative design.

Thirdly, the phase of "Change" mainly transforms knowledge into creativity. It entails the conducting of an analysis of cultural characteristics, the connection of the product context, and the selection of suitable concepts, such as contents. Then, the practical teaching creation by means of metaphor, allusion, metonymy, and simulation is conducted. Specifically, this phase provides actionable specific models for practice. It takes the application of product semantics as a method to link the cultural messages conveyed by the product in order to visualize the design concept with attributes.

Fourth, the stage of "Comprehensiveness" mainly entails converting creativity into intelligent value. Here, the execution of the design and the proposal of the design finalization as content, the conducting of culture transformation, structuring transformation, and connotation conversion are all completed. The cultural characteristics are expressed using color, texture, surface ornamentation, lines, details, composition of components, modeling, etc. The design concept includes the handling of functionality, structure, safety, operation, and bonding relationships, as well as where the design incorporates connotation, storytelling, and emotion into appropriate products in order to reinforce the creative design process. Ultimately, the design embraces the depth and breadth of the culture it originates from.

Finally, the evaluation and reflection stage of the industry applies the teaching achievements to the consideration of industry so as to deepen the integration of industry and education. This stage is an evaluation survey of the cultural product design from the consumer's side, as well as a preliminary assessment of the possibility of product improvement and mass production. In addition, the basis for evaluation may refer to the communication model proposed by linguist Jakobson [47], which summarizes six factors that make up the communication process and describe the flow of messages between distributors and recipients.

Specifically, this research discusses the issue of modern art education by drawing on the eastern philosophical thinking of the "Tao, Vessel, Change and Comprehensiveness" in the Book of Changes. This provides a new methodological guidance for solving the problem, which is valuable for guiding the theory and practice of contemporary cultural and creative design education. Second, by recognizing and understanding the dialectical relationship between "Tao", "Vessel", "Change", and "Comprehensiveness", this research brings this concept into creative design teaching as a consensus. Likewise, it guides contemporary talents in design practices, allowing them to form innovative ideas and design methods with philosophical connotations based on Chinese philosophical thinking. Additionally, this research constructs a teaching model of cultural and creative design with Chinese philosophical outlook, forming a design teaching concept unique to Chinese, thus promoting the inheritance and development of Chinese culture in design, enhancing the soft power of cultural communication, and gradually developing the aesthetic cultural economy.

In this research, traditional Chinese thinking with modern design experience was subtly combined. The intrinsic thoughts of Chinese civilization was explored and were applied innovatively, especially in regard to the systematic research of design education, methods, and concepts, which are required when seeking new ideas and directions for the purposes of modern design teaching. The constructed teaching model not only allows the designer to create design application serving as a basis for cultural product design, but also helps them develop diverse modes of thinking and potential creativity in practice. The design thinking of "Tao, Vessel, Change and Comprehensiveness" highlights the subtle wisdom of the ancients. The design thinking model constructed in this research not only conforms to the traditional view of design, but also innovatively transforms it, with a view to forming an influential Chinese design by combining aspects of Chinese culture and thought. This research provides a scientific basis and systematic method for the purposes of teaching and practice in the field of design. Additionally, it advocates an educational approach combining theory and practice, of which the research findings are expected to bring a new practical guidance significance to the cultivation of talents in regard to cultural and creative design.

6. Limitations and Prospects

In the future, the researchers plan to promote the teaching model constructed in this research to the cultural and creative design teaching. The effectiveness of the model will be examined through the diversity of design applications, and its rationality and operability will be verified through multiple design practices. However, there are still weaknesses in this research, and the current research only cites two case studies for exploration and verification, which is somewhat limited. The researchers will use the model in subsequent courses to conduct design transformations of other cultural assets, such as poetry, Chinese characters, and regional intangible cultural heritage, and verify the effectiveness of the model. Moreover, the researchers will conduct a further in-depth study, taking the teaching process and outcomes of the instructed students as a case study. The purpose is to explore the effectiveness of this teaching method, the cognitive experience of students' learning, and to summarize the problems that arise in teaching as well as new possibilities for implementing this teaching method. In addition, subsequent research can analyze the marketization of the designed products so as to understand the relevant factors of the audience's preference and emotional experience for them, and then improve the product design and explore new possibilities of design methods.

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Article

A Study on the Effects of Digital Learning Sheet Design Strategy on the Learning Motivation and Learning Outcomes of Museum Exhibition Visitors

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Abstract: This study focuses on "digital learning sheets" by exploring the effects of different design strategies of the digital learning sheet on visitors' motivation and learning outcomes. This study chose the woodcraft themed exhibition as a case study, adopting the learning sheet design principles proposed by Hooper-Greenhill in order to design three types of digital learning sheets for this exhibition. A control group of students who did not use the sheets and three experimental groups of students who used the sheets were invited to visit the exhibition for the purpose of examining the impact of different strategies of digital learning sheet design on the "learning motivation" and "learning outcomes" of the visitors. The study results show that among the four learning motivations of Attention, Relevance, Confidence, and Satisfaction, the digital learning sheet designed with the "principle of sensory exploration of physical objects" had the highest effectiveness among the various design strategies. In terms of three aspects of learning outcomes: Cognitive, Affective, and Psychomotor, the three types of digital learning design strategies do not produce significant differences in the affective impact on children. As for Cognitive and Psychomotor, students learn best when they use digital learning sheets designed with the "design principle of sensory and exploration of physical objects". The results of this study will provide future exhibition planners, digital learning designers, and educators with precise and practical references.

Keywords: digital learning sheet design; museum exhibition planning; informal education; learning motivation; learning outcomes

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1. Foreword

A city that is constantly moving forward and improving towards a better vision requires a sound education infrastructure as well as citizens with a lifelong learning mindset. The development of learning cities is related to the issues of sustainable development and global citizenship [1]. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), holistic learning strengthens citizenship, social integration, economic development, cultural prosperity, and sustainable development [2,3]. Museums in cities play a vital role in both universal education and lifelong education. Hooper-Greenhill et al. [4] point out in "Museums and Social Inclusion: The GLLAM Report" that exhibitions and educational outreach activities can promote egalitarianism in social education. In addition, to assist school children to learn in a contextualized, non-formalized, and spontaneous way and provide a learning environment that is different from the school education model, the museums are capable of contributing to social education and culture. Moreover, they can provide professional, public, and diversified educational

resources for socially disadvantaged individuals, groups, and organizations, and enhance the competitiveness of the national society [5].

An exhibition "learning sheet" is an educational material that combines the functions of guiding visitors for reading, exhibition participation, interaction, observation, reflection, debate, and even advertisement, and has been widely implemented in major museum exhibitions around the world. A quality digital learning sheet design can enhance effective information transfer, educational learning, learning motivation and outcomes; while a poor quality digital learning sheet design may eliminate the characteristics and values of museum exhibitions, educational benefits, and could mislead users in the wrong direction of the exhibition learning process and outcomes. Learning sheets are crucial to the promotion of education in exhibitions, but with the pace of modernization, the use of digital learning sheets remains rare, at least in Taiwan where no museums have yet provided "digital learning sheets" for citizens. Although the use of digital learning sheets might have increased some costs, in the digital era, we believe that highly interactive and interesting digital learning sheets can significantly enhance the learning effectiveness of the visitors. We saw the importance of investing in such a study and were motivated to research towards the goal of how museums can design effective digital learning sheets [6].

The National Taiwan Craft Research and Development Institute (hereinafter, NTCRI), established for research, education, exhibition, collection and preservation, is located in the central part of Taiwan, where the craft industry is flourishing and is an important representative of Taiwan's regional museums. In this study, we chose the "Exhibition of Taiwan's Woodcrafts" organized by the NTCRI as a case study. In the first stage of the study, we first conducted participatory observation method to understand the process of the exhibition curation and the establishment of educational purposes. In the second stage, we explored the effects of different strategies for designing digital learning sheets and their impact on visitors' learning motivation and outcomes [7]. In summary, the objectives of this study were to:

1. Explore how the exhibition objectives correspond and integrate with the educational objectives and educational contents in the exhibition planning framework.
2. To understand how different digital learning sheet designs affect the learning motivation and learning outcomes of student visitors.

2. Literature Review

2.1. The Education of Museums

Museums have a history of more than 2000 years, and the earliest museum in the world, The Mouseion of Alexandria, was established in 290 BC by the Egyptian king Ptolemy Soter for royal collections, research, and lecturing purposes [8,9]. With the spread of the knowledge of educational equity, museum scholar Hooper-Greenhill proposed the "post-museum" discourse in 2000, and began to reflect on and criticize the identity of modern museums. According to the post-museum discourse, the nature of the exhibition is believed to be completely open-themed, free, and random, and provide the audience with the knowledge to explore from it [4]. Contemporary museums should be able to respond to the development needs of society, transforming from the object-oriented management mindset of the past to an object-oriented strategy, as well as thinking about the visitor orientation, so that a high level of communication between the audience and the exhibition becomes the main axis of thinking in contemporary museums. The International Council of Museums' (ICOM) definition of a museum [10], adopted by the 22nd General Assembly in Vienna, Austria, on 24 August 2007, is as follows: "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment (2021)". Graeme K Talboys [11] believes that museums play an important role in active cultural interpretation and social communication education. The existence of museums is desired by the general public, and for educational purposes, they carry out operational

behaviors such as acquisition, conservation, maintenance, research, communication, and exhibition. Contemporary museums focus not only on the single aspect of exploration and export of knowledge through acquisition, research, preservation, and demonstration. As early as 1992, the American Association of Museums highlighted in "Excellence and Equality: Education and the Public Dimension of Museums", the importance of social service in terms of museum operations. Since then, the orientation of museums began to focus on their involvement in the development of local communities and on issues of local community events, community identity, and connections as well as the establishment of social networks [12]. Today's museums should think beyond the framework of exhibition in buildings, focusing on their social functions, displaying various records of people and the environment, and reinforcing conceptual aspirations and cultural values, which is why many community museums, regional museums, folk museums, neighborhood museums, school museums, etc., have been established successively. In a message delivered by Alberto Garlandini, President of ICOM on the occasion of International Museum Day in May 2021 [10], he mentioned that the imagination of future museums must be constructed today, and that museum professionals are working for innovative social activities, digitization, new cultural experiences, and complex forms of communication.

Museums are an important asset for local development, and their cultural significance relates to identity, knowledge, emotion, and life in the development of society as well as the intangible cultural heritage of the exhibitions they operate and the dialogue they have with the community. However, the operation of museums is a complex system, which specifically emphasizes cross-disciplinary integration, and postmodern museums may involve various disciplines, such as sociology, culturology, anthropology, semiotics, art education, management, integrated marketing, digital media technology, and other fields; moreover, it combines theoretical exploration and operational practices [13]. The development of museums should be based on the long-term development goals of the local area, city, and even nation.

In the case of museum development in Taiwan, the "Social Education Act" [14] promulgated in 1953 defined museums as one of the social education institutions and could be established by the central or local governments for the purpose of promoting cultural construction, cultivating artistic interests, popularizing technological intelligence, and 18 other social education tasks. In the 2002 "Lifelong Learning Act" [15], museums are classified as one of the types of lifelong education organizations, contributing to lifelong education and social education. In 2016, Taiwan promulgated the "Museum Act" [16] which defined museums in Taiwan as non-profit institutions engaged in the acquisition, conservation, restoration, maintenance, and study of tangible and intangible evidence of human activities and the natural environment, and that are open on a regular basis for the public for the purpose of exhibition, educational promotion, or other uses. In particular, it emphasizes that museums should enhance educational and scholarly functions and improve communication with the public to achieve the purpose of cultural heritage transmission, art promotion, and lifelong learning; and it recommended methods such as "undertaking research related to the museum's purpose or established theme", "transforming research results into content for exhibitions or archived collections", "carrying out education promotion activities or publication of relevant materials" to achieve educational goals.

The emphasis on education is an important transformation in the operation of museums after the 1980s. Museums have become units of public learning as part of a joint effort promoting education [17,18]. Unlike the institutionalized teaching model of schools, museums maintain flexibility and are able to plan different exhibitions and activities for different themes, ethnic groups, and educational purposes, and set specific periods for exhibitions and activities. Museums, in particular, provide visitors with a high degree of experiential participation, making visitors the subjects of exploration, experience, and interaction, actively acquiring diverse and meaningful intellectual cognition and experience from the exhibition, and even generating self-identifying emotional responses, which sometimes have more innovative possibilities with informal education models [19].

From the viewpoint of museum education, the interactive experience model proposed by Falk and Dierking [18] in "The Museum Experience" is one of the important learning processes, which focuses on the interaction between three contexts, which are personal context, social context, and the physical context of the museum, of which interactive experience is formed. As for the participatory experiential learning model, it has been interpreted by Kolb [20], who argues that learning from reflection on doing emphasizes the importance of experiential learning and that the learning process is built on past experiences of life and new experiences. Based on the abovementioned scholars' perspectives, if we were to explain the process of museum knowledge transmission from the viewpoint of cognitive theories, we might benefit from the viewpoint of Constructivist Learning Theory. In other words, the exhibitions provided by museums are characterized in various ways such as materiality, narrativity, sociality, activity, and multimodality. These characteristics can induce visitors to participate actively and meaningfully and to enjoy the context of the exhibition as well as the knowledge it provides [21,22]. Hence, this study argues that the process of knowledge construction by visitors in museums must involve a combination on three aspects: past knowledge and experience, the context of the socio-cultural environment, and new knowledge experienced through participation in exhibitions [23].

2.2. Educational Tools for Museums: Learning Sheets

In the process of visiting an exhibition, visitors participate with their thematic interests and concepts according to the attractiveness of exhibits, level of concern, time scheduling, and spatial configuration [18]; however, if we look at it from the perspective of education or information transmission, there are many "noises" in the exhibition environment that might decrease visitors' commitment to the exhibition. The learning sheet in the exhibition serves as an important medium of communication between visitors and the exhibition. Through logical, purposeful, and systematic design, visitors will be able to follow the guidance of the learning sheet and become more engaged in the exhibition. However, learning sheets are supplementary tools for education and learning and the design of learning sheets deserves more attention. If they are designed like flyers, or fail to highlight the context of the exhibition theme or fail to relate to the life experience of the visitors, they will not be of any benefit.

A museum exhibition learning sheet can be designed for different educational purposes, including extended, integrated, exploratory, and activity-based learning sheets. The format can vary according to convenience, operativity, interactivity, and effectiveness, such as booklets, leaflets, folders, and other printed formats, or presented on digital carriers, or even downloaded by visitors from their cell phones. In terms of learning sheet content and question design, Grinder and McCoy [24] suggested four types of question design, which are memory questions, integrated questions, open-ended, and creative questions as well as critical and evaluative questions. Museum curator Hooper-Greenhill [25] emphasizes that visitors should use various senses to learn from exhibitions, and believes that the museum learning model can be divided into five levels, which are: stage 1, sensory and exploration, stage 2, discussion and analysis, stage 3, memory and comparison, stage 4, deep thinking from different cultural backgrounds, and stage 5, cross-field interaction and application. If we examine the four stages of cognitive development, which are proposed by Piaget, the senior of elementary school to the middle school level can already adopt an egocentric viewpoint and they are capable of hypothesizing, interpreting, reasoning, and systematically organizing, comparing, and solving knowledge learning problems. Hooper-Greenhill [25] also proposed three aspects of the question design of the learning sheets, which are 1. a sensory exploration of physical objects, 2. memorization, comparison, and integrative association, and 3. problem discussion, analysis, and integrative comparison and commentary. This perspective also offers important guidelines for the design of the digital learning sheets.

2.3. Perspectives from Learning Theory

Learning theory provides abundant insights into the practical work of museums in planning exhibitions. This article explores the various possibilities of museum exhibitions for visitor learning from three perspectives of learning theory. The three perspectives include "constructivist learning theory" which explores the learning resources available to visitors at the exhibition. The "educational goal theory" discusses the different components of education and learning goals that the exhibition can provide. The "learning motivation theory" focuses on how the exhibition enhances various learning motivations, attitudes, and behaviors of visitors.

2.3.1. Constructivist Learning Theory

Museum exhibitions provide visitors with an informal, spontaneous, and enjoyable learning environment. Exhibition curators must consider how to present the exhibited objects' content, knowledge, spirit, and affection through the integration of different methods, media, space, and target audiences, so that visitors can have the opportunity to reconstruct new knowledge frameworks and cognition through the process of visiting and experiencing. Throughout the process, visitors must constantly carry out the tasks of cognitive "assimilation" and "adjustment" of cognitive reconstruction through the information received and interpretation strategies of Prediction, Observation, and Explanation (also known as POE strategies) [26,27]. We can thus conclude that museums provide important learning resources for situated learning just as Lave and Wenger [28] further pointed out that situated learning can be a result of the interaction of activity, context and culture. In addition to the process of personal knowledge construction, museum exhibition design can also create the benefits of cooperative learning through collaboration, work sharing, communication, and debating among visitors under the guidance of planned social interaction [29].

Lev S. Vygotsky (1896–1934) and Jean Piaget (1896–1980) are praised as the most important scholars of the constructivist learning theory in the late twentieth century, and their ideas about the cognitive construction of learning have received much attention in museology. Vygotsky's theory of social construction emphasizes the significance of social activities and three important points made by Vygotsky are critical references for museum exhibitions. Firstly, the "Egocentric Speech" or so-called inner-dialogue, as Vygotsky argues, is beneficial in guiding children's thinking and actions in their learning process. Therefore, if the process of visiting an exhibition can induce children to state their inner thoughts, express and discuss them, it may become a strategy conducive to learning. Secondly, the "Zone of Proximal Development (ZPD)", refers to the gap between children's current knowledge level and the knowledge level they can achieve after being taught by others. Lastly, the "Scaffolding", which is the importance of the instructor in the learning process as suggested by Vygotsky, who believes that a teacher or a more capable peer who provides appropriate assistance will help children's learning [23,30,31].

In Piaget's Genetic Epistemology, the internal learning process is described in terms of "Organization" and "Adaptation". The "Organization" refers to how people organize their experiences and knowledge into logical combinations and define the relationship between each other logically so that people can complete their work efficiently when facing difficulties. "Piaget believes that cognitive development is a cumulative process that builds on existing knowledge (or Schemata) and continues to construct larger or deeper knowledge structures. Piaget considers this as a "theory of self-regulation" in which coordination can be divided into two processes: "assimilation" and "accommodation". In addition, Piaget further divided the cognitive development of children and adolescents into four stages, namely: "Sensory-Motor", which is about 0–2 years old, and is characterized by sensory and motor functions, mostly instinctive reflex behaviors; "Preoperational", which is about 2–7 years old, in which stage children can gradually express and use symbols verbally, but their thinking ability is not fully logical yet; "Concrete Operational" is about 7–11 years old, in which stage they can think concretely and have the ability to think in reverse; "Formal Operational" is about 11–15 years old, at which time they can do abstract

thinking. They can solve problems in a hypothesis-tested scientific way, and think through logical rules [32–35]. Some museums have developed based on Piaget's learning theory, such as the Boston Children's Museum, San Francisco Children's Discovery Museum, and the Children's Creativity Museum. Thus, museums must consider not only the theme and content of the exhibition, but also the presentation methods and media, the age of the visitors, the cognitive schemata, the learning background, and even the educational system and system implemented by the society as a whole, to provide appropriate exhibition.

2.3.2. Perspectives from Educational Objectives

From an educational point of view, the designing of educational content is often considered from a "goal-oriented" and "process-oriented" perspective. A "goal-oriented" educational content design emphasizes the outputs and outcomes of learning and the goals that the educational content is intended to achieve are predetermined before the educational content is designed. On the contrary, "process-oriented" education emphasizes the process of learning, experience, and inquiry as well as the level of engagement of the learners. The American educator Tyler proposed the principles of content design and the Tyler Evaluation Model in his book *Basic Principles of Curriculum & Instruction*, which reminded one of the importance of establishing educational goals, selecting learning experiences, organizing learning experiences, and conducting the evaluation [36]. Such a model provides an important reference reminder for exhibition planning.

In 2015, the Taiwan National Academy for Educational Research promulgated the "curriculum guidelines of 12-year basic education general guidelines: core competency development handbook" to provide a reference for education in various fields. "Core competency" as defined in the handbook refers to an ability to meet various needs in life, including the ability to use knowledge, cognition, and skills, as well as attitudes, affections, values, and motivations. In the manual, it is emphasized that learning performance in achieving educational goals should be examined and evaluated along three dimensions: the "cognitive process dimension", the "affective dimension", and the "psychomotor dimension. These three learning performance dimensions are based on Bloom, Krathwohl, and Simpson's theoretical division of teaching objectives into three domains: cognitive, affective, and psychomotor domains [37–39].

A research team led by Benjamin Samuel Bloom (1913–1999) published *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain* in 1956. "Cognitive Domain" provided an important reference for educators from the perspective of learning objectives and assessment, and its classification system divided the cognitive domain into six levels according to different levels of performance. Forty-five years later, Anderson and Krathwohlh published "A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Educational Objectives", in which the cognitive objectives were divided into the Knowledge Dimension and the Cognitive Process Dimension. The Knowledge Dimension is divided into four categories: Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Meta-cognitive Knowledge, reminding educators and curators of the importance to think about what to teach when planning the content of education; whereas the Cognitive Process Dimension is divided into six categories: Remember, Understand, Apply, Analyze, Evaluate, and Create, reminding educators of the significance of how educational content could motivate learners of retention and transfer knowledge [39].

2.3.3. Learning Motivation and Outcomes

Museums feature the qualities of informal education, including the following characteristics: (1) visitors are free to choose their learning ways and means in an informal education context; (2) it is a place without the pressure of assessment and competition as in school education; (3) the learners' appreciation of learning can be supported by the exhibition environment and information. In museum exhibitions, visitors have the power

of free-choice learning, choosing and controlling the content and methods of learning based on their interests and needs [18,40].

Museums play a role as educators in society. Hooper-Greenhill [41] suggested that modern museums are crucial in an inclusive society, supporting the lifelong learning of different groups. Therefore, the activities and exhibitions planned by museums must interact with the public in an adequate and age-appropriate educational manner. The services that museums can provide through different information and computer technologies should be improved; to provide an environment that enables audiences to learn, form motivation and generate interest in learning [4,42,43]. Scott [44] regards museum resources, displays, and related educational activities as "products" that museums provide to the public, and emphasizes the idea that learning outcomes should be valued as an educator. In museums, learning outcomes refer to the various tangible and intangible takeaways that visitors receive through the "products" of the museum. Therefore, to examine the degree to which visitors acquire from the various types of "products" offered by the museum, the assessment of learning motivation and learning outcomes is used as evidence to observe the progress of these visitors [45,46].

The motivation to learn is the driving force that causes learners to engage in learning behaviors. Museum exhibitions that make good use of learning sheets as a tool to guide visitors through the learning process and focus may inspire visitors to explore the contents of the exhibition. In general, learning motivation can be divided into Intrinsic Motivation (or regarded as personal variables), which is the drive to learn and it is promoted by the learner's intrinsic needs, such as the desire to learn; and Extrinsic Motivation (or regarded as environment variables), which is the desire to learn due to external environmental stimuli, inducements, and guidance [47]. Keller [48] once used the ARCS motivation model to explain people's motivation to learn. From the viewpoint of museum exhibition education, the "A" stands for attention, which means to consider the attractiveness of the theme, content, aspiration, and form of the exhibition whether it catches visitors' attention and curiosity. The "R" stands for "relevance" which means to consider how the content of the exhibition may engage visitors' personal needs, life, and produce meaningful relevance. "C" stands for confidence that the ability of visitors should enable them to participate in various learning activities in the exhibition with moderate difficulty and challenge. "S" stands for "satisfaction", which is the satisfaction that the exhibition provides, in terms of the pleasant experience, spiritual enhancement, and knowledge learning satisfaction that visitors can get from the process of visiting the exhibition [49,50]. In this regard, Dörnyei [51] points out that the satisfaction of learning is fundamental to the motivation of learning because it confirms that the learner's efforts and the whole learning process are directed towards a goal, purpose, and value.

3. Study Methodology

This study was conducted in two stages for the purpose of examining the impact of different digital learning sheet design strategies on the learning outcomes of visitors to the exhibition. In the first stage of the study, we participated in the process of planning, designing, and setting up a professional exhibition by using the participatory observation method to analyze how the people in practice operate and sort out the curatorial model. The second stage of the research is based on the research hypothesis proposed in this study. The methodology of the two stages of the study is explained as follows.

3.1. Framework and Hypotheses

This study examines whether the design strategies of different digital learning sheets have an impact on the learning outcomes of the school children who visit the exhibition. Drawing from the literature review, this study chose the principles of learning sheet design suggested by Hooper-Greenhill to design the digital learning sheets for the exhibition and to provide the children who visited the exhibition with digital learning sheets on their iPads. Such a learning sheet is different from the conventional paper-based format and

will provide more interactive, audio-visual, and hyper-linked information to give school children more diversified, interesting, and intimate ways to learn. For the purpose of this study, the following research framework diagram (Figure 1) is proposed based on the previous discussions of related theories.

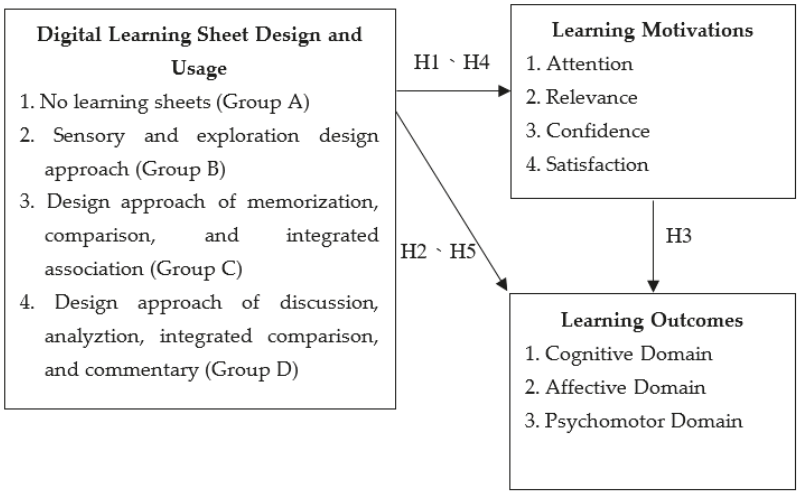

Figure 1. Research Framework.

In Figure 1, the relationship between the concepts of "design and usage of digital learning sheets", "learning motivation", and "learning outcomes" is presented in the framework of the study. In the first phase, the researcher participated in the "Exhibition of Taiwan's Woodcrafts" organized by the NTCRI, which was established in 1954 as a regional museum for research, education, exhibition, and collection. This study was based on the educational objectives of the "Exhibition of Taiwan's Woodcrafts", and the study was conducted through expert meetings and the design of digital learning sheets for the exhibition was based on the principles of learning sheet design suggested by Hooper-Greenhill. Students were provided with digital learning sheets on iPads to use in the exhibition. In the second phase, students aged 11 to 15 were invited to the exhibition, and a total of four groups of students participated (groups A, B, C, D). One of the four groups of students are designated as the "control group" (group A) who did not use the digital learning sheets. The other three groups of students were designated as the "experimental group" (groups B, C, and D) who used digital learning sheets designed with different design principles (Appendices A–D). The purpose is to verify the influences of different digital learning sheet design principles on the motivation and learning effectiveness of the students. Details of the study design will be described in the next section.

To investigate the relationship between the concepts of "design and usage of digital learning sheets", "learning motivation", and "learning outcomes", this study was empirically conducted and proposed the following research hypotheses:

H1: *The "learning motivation" of the group with digital learning sheets is significantly higher than that of the group without digital learning sheets.*

H2: *The "learning outcomes" of the groups with digital learning sheets were significantly higher than those of the groups without digital learning sheets.*

H3: *Regardless of the use of digital learning sheets or not, "learning motivation" has a significant and positive impact on "learning outcomes".*

H4: *There is a significant difference in the effect of different "digital learning sheet design strategies" on "learning motivation".*

H5: *There is a significant difference in the impact of different "digital learning sheet design strategies" on "learning outcomes".*

In the final part of this study, we will comment on the potential benefits and changes in the practice of these digital learning sheet design strategies for museum exhibitions and educational activities, as well as giving suggestions for future use.

3.2. Research Process

According to the purpose of this study, two-stage research processes were conducted. The first stage is the researcher's participation in the exhibition curation of the "Exhibition of Taiwan's Woodcrafts", to gain an in-depth understanding of the starting point, motivation, purpose, creative ideas, and exhibition design planning; with in-depth participation of curating the exhibition such as visual design, interactive design, spatial planning, and exhibition service flow, etc., we have summarized the "Art Craft Value Level and Exhibition Structure Relationship Diagram" of the "Exhibition of Taiwan's Woodcrafts" project, and this provides an important basis for the second stage of research. (The exhibition period of "Exhibition of Taiwan's Woodcrafts" is: 30 April 2021 to 17 October 2021.)

In the second stage of the research, the "Exhibition of Taiwan's Woodcrafts" was the subject, and three types of digital learning sheets were designed according to the design principles suggested by Hooper-Greenhill. The main goal of such a design is to develop a digital learning sheet in HTML and JQUERY that can be used on iPads. The digital learning sheets designed by the Institute are different from the printed learning sheets by offering users of digital learning sheets a more user-friendly interactive interface, such as the use of friendly fill-in answers and the use of hyperlinked information (video, text) for extended reading and other interactive content.

The study was conducted by inviting upper elementary school children and junior high school children in central Taiwan, aged between 11 and 15 years old, to be tested from 20 May to 17 September 2021. The subjects were divided into four groups and the testing period did not overlap to avoid interferences. Among the four groups, one of them was the control group of "no learning sheet" (Group A) with 81 participants, while the other three groups participated in different experimental groups with 84 participants in the "sensory and exploration design approach" (Group B), 77 participants in the "design approach of memorization, comparison, and integrated association" (Group C), and 75 participants in the "design approach of discussion, analyzation, integrated comparison, and commentary" (Group D). The number of participants in this study was 317 in total. Before visiting the exhibition, each group of students completed a "pre-test questionnaire" to find out what knowledge they knew about the "Exhibition of Taiwan's Woodcrafts". After the pretest, the students were guided by professional guides on how to operate the digital learning sheets and were guided through the exhibition tour, as well as the reading, filling, and discussion of the digital learning sheets. After each group visit, a "post-test questionnaire" was then conducted to examine the progress of the students' learning outcomes.

3.3. Research Tools and Analysis Strategies

3.3.1. Review of Learning Outcomes

To examine the learning outcomes of the four groups of students, A, B, C, and D, after visiting the exhibition and using the digital learning sheet, the study adopted the ARCS model of learning motivation theory and the development of the three dimensions of learning effectiveness: cognitive, affective, and psychomotor. The "pre-test questionnaire" and "post-test questionnaire" were designed with different questions and were given to groups A, B, C, and D to fill out before and after the visit with 4 questions each on the 4 aspects of attention, relevance, confidence, and satisfaction, using Likert's 5-point scale; and 5 questions each on the three aspects of cognition, affect, and psychomotor, using

multiple-choice questions for a total of 31 questions. Among them, we designed 3 reverse questions in order to examine the reliability of the respondents' answers.

The analysis of learning effectiveness in this study was based on the "increase in the number of correct questions" in the cognitive, affective, and skill dimensions of the post-test questionnaire compared to the pre-test questionnaire.

3.3.2. Digital Learning Sheet Design

Based on the three different learning sheet design principles proposed by Hooper-Greenhill, this study was conducted to design and produce digital learning sheets on the educational and knowledge contents of the "Exhibition of Taiwan's Woodcrafts". The information contained in the three different learning sheets, such as extended readings and videos, were all consistent in order to avoid research bias caused by information differences. The design process of the digital learning materials was discussed and designed in the form of expert meetings with the participation of curators, university teachers of educational fields, elementary school teachers, junior high school teachers, visual and interface designers, engineers, and our researchers for a total of seven people. The focus and content of each of the three different study sheet designs are briefly described as follows.

"Sensory and Exploration Design Approach" (Group B): The 18 questions in this learning sheet are designed to highlight the process of guiding students to respond to the questions, and to explore and learn through the five senses when visiting the exhibition. It is anticipated that the students may construct an integrated concept in the process of exploration. For example, students are encouraged to explore the weight, aroma, and sound of each type of domestically-produced wood as well as try out wooden furniture, toys, and utensils, while considering the characteristics of the wood and processing techniques behind these exhibits.

"Design Approach of Memorization, Comparison, and Integrated Association" (Group C): This 16-question learning sheet is designed to emphasize the comparison between the new knowledge learned in the exhibition and students' past experiences, and to stimulate expanded thinking and discussion among students and their peers. The discussion of the comparison, correlation, and the cause and effect of different knowledge is also designed in the contents of the learning sheet. For example, students were asked if they could recall any household items made with the techniques of mortise and tenon joints; or questions about their memories of observing natural plants at different altitudes in the past.

"Design Approach of Discussion, Analyzation, Integrated Comparison, and Commentary" (Group D): This learning sheet consists of 16 questions. The design of the contents emphasizes guiding students to observe, analyze, and examine the questions so that they can read further the various information provided in the exhibition and further guide them to have group discussions, comments, and critiques through learning sheets. For example, how can we fulfil our responsibility to protect the environment in our lives? How can different wood tools be used? How does mechanical production compare with manual production? As well as designing a table by yourself and other contents.

3.3.3. Reliability Analysis

The total number of questionnaires collected in this study was 317, excluding the invalid questionnaires due to omission or incorrect completion of the reverse question, the total number of valid questionnaires was 312, and the recovery rate was 98.4%. To examine the consistency of the questionnaire content in the "Learning Motivation ARCS" section, the study first examined the internal consistency of the questionnaire using Cronbach's alpha reliability analysis. The results of the reliability analysis showed that the overall reliability of the questionnaire reached 0.916, and the reliability values of each measure were greater than 0.7 (Hee, 2014) (Table 1), indicating that the results of the questionnaire analysis are reliable. Subsequently, Pearson correlation coefficient analysis was chosen for the validation of the study hypothesis (H3) and one way ANOVA was chosen for the mean difference (H1, H2, H4, H5).

Table 1. Reliability Analysis of Learning Motivation ARCS Measurements in Four Groups.

Learning Motivation	Cronbach's Alpha	
A	0.857	0.916
R	0.805	
C	0.887	
S	0.840	

4. Research Analysis

4.1. The First Stage of Study: The Interpretation of the Development of Taiwan Woodcraft Industry with the Concept of Survival, Living, and Philosophy of Life

In the first phase of this study, the researcher joined the curatorial team of the "Exhibition of Taiwan's Woodcrafts" as consultant and exhibition curator since March 2021, and participated in exhibition meetings, planning, exhibition execution, opening activities, and volunteer guide training. Through participatory observation, we attempt to acquire in-depth understanding of the curatorial team's planning process and the implemented exhibition themes, motives, objectives, as well as creative ideas through exhibition design planning participation such as visual design, interactive design, spatial planning, exhibition service flow, etc. The period of participation was March to May 2021.

During the period of participation, we collected meeting reports, audio recordings, textual materials, and exhibition design plans, and conducted textual analysis to analyze how the professional curatorial team could use the exhibition's contents and presentation methods to communicate wood craft knowledge to visitors.

The study found that the objective of the "Exhibition of Taiwan's Woodcraft" was initially to invite works from the academic, industrial, and artistic fields; later, through the planning process, the curatorial group gradually made clear the knowledge contents and information that the exhibition intended to convey; and then to confirm the exhibited works, exhibition formats, graphics, videos, and interactive details, while gradually organizing the exhibition structure and spatial layout. The curatorial framework of the "Taiwan Woodworking Exhibition" was built upon the Three Extreme Systems of the "Book of Changes" and "Tao Te Ching", written by Lao Tzu, which states that "Tao gives birth to one, one to two, two to three, and three to everything". The central idea was that all things bear the yin and embrace the yang, as they achieve harmony by combining these forces. The curatorial team developed the exhibition from traditional Chinese ideology and divided the value level of crafts into three levels, which are "Tools for Livelihood", "Ways of Living", and "Philosophy of Life", and developed the exhibition objectives and demands into three exhibition areas, such as "Knowledge Learning and Exploration", "Daily Life Application and Connection", and "Spiritual Practice and Pursuit", and planned the exhibition contents of each section accordingly.

In this study, the curatorial structure of the exhibition is reviewed, and the "Art Craft Value Level and Exhibition Structure Relationship Diagram" is proposed as shown in Figures 2–8 below.

Figure 2. In this study, three digital learning sheets were designed based on Hooper-Greenhill's suggestions for the design of learning sheets, and the IPADs were used by visiting students.

Figure 3. The tour guide first guided the students on how to use the digital learning sheets, then guided them step by step through the questions during the tour.

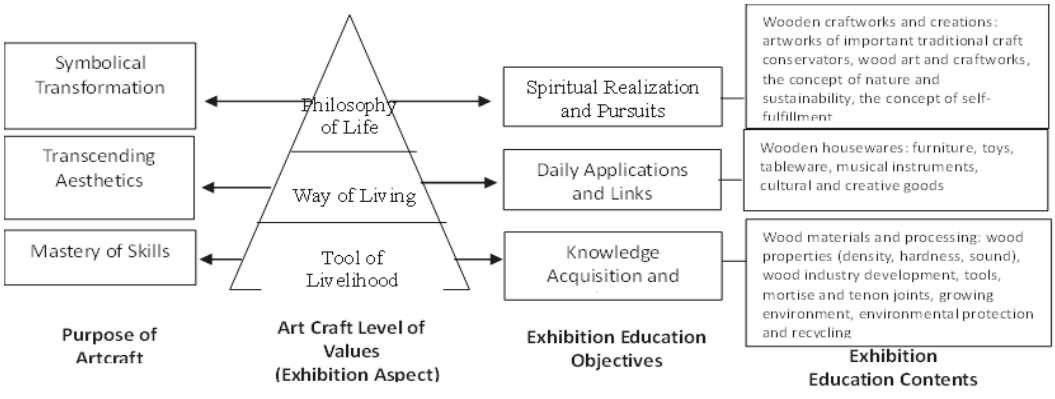

Figure 4. Art Craft Value Level and Exhibition Structure Relationship Diagram.

Figure 5. Tools of livelihood exhibit section planned with a wood material lab, providing hands-on interaction for the public to learn about various wood properties.

Figure 6. Tools of Livelihood exhibition area, including the knowledge of wood industry development.

Figure 7. The Way of Living section features an introduction to the use of various wood materials in living and innovative designs.

Figure 8. Philosophy of Life section, focusing on artists' creations and discourses.

4.2. The Second Stage of the Study: Verification of Research Hypotheses

4.2.1. Research Hypothesis 1: The "Learning Motivation" of the Group with Digital Learning Sheets Is Significantly Higher than That of the Group without Digital Learning Sheets

This hypothesis was designed to test whether there was a significant difference in the learning motivation of the students who did not use the digital learning sheets (Group A) compared to the other three groups of students who did use the digital learning sheets (Groups B, C, and D) after visiting the exhibition. In this section, the study analyzed independent samples by *t*-test to see if there were any significant differences between the "learning motivation of group A students" and the "mean of learning motivation of groups B, C, and D students"; the results of the statistical analysis are summarized in Table 2.

Table 2. Mean number of "learning motivation" between "no learning sheet" and "using digital learning sheet".

	Levene's Equality of Variances Test		**The *t*-Test for Equality of Means**						
	F	**Significance**	**t**	**df**	**Significance (Two-Tailed)**	**Average Difference**	**Standard Error**	**95% Differences Confidence Interval**	
								Lower Limit	**Upper Limit**
Using Equal Variances	2.043	0.155	−19.263	163	0.000	−0.80290	0.04168	−0.72060	−0.88521
Not using equal Variances			−19.186	153.010	0.000	−0.80290	0.04185	−0.72023	−0.88558

The results of the analysis showed that group A students had a average learning motivation of 2.7948 after visiting the exhibition, while groups B, C, and D students had an average learning motivation of 3.5977, which was significantly higher than group A students. Table 2 summarizes the results of the independent sample *t*-test, where the F-test was not significant (F = 0.155 > 0.05), so the t-value of "equal variance" = −19.263, where a negative number indicates that the mean of group A is lower than that of groups B, C and D. In terms of significance, it shows that a significant level of 0.000 was reached between the two groups. In other words, this indicates that there is a noticeable difference between the two. This means that hypothesis 1 of this study that the "learning motivation" of the group with digital learning sheets is significantly higher than that of the group without digital learning sheets holds true. This indicates that if learning sheets are used properly in the exhibition, it will help improve the overall learning motivation of visitors.

4.2.2. Research Hypothesis 2: The "Learning Outcomes" of the Groups with Digital Learning Sheet Are Significantly Higher than Those of the Groups without Digital Learning Sheet

This hypothesis examines whether the overall learning outcomes of the students who used the digital learning sheets (groups B, C, and D) were significantly higher than those who did not use the digital learning sheets (group A).

To calculate the learning outcomes of this study, the number of correct questions in each section of the "post-test questionnaire" after the visit to the exhibition was compared to the "front questionnaire" before the visit to the exhibition.

In this section, the study also used independent sample t-testing to examine whether there was a significant difference between the "learning outcomes of group A students" and the "mean learning outcomes of groups B, C, and D students", and the results of the statistical analysis are summarized in Table 3.

Table 3. Average of "Learning outcomes" Between "No Learning Sheets" and "Using Digital Learning Sheets".

	Levene's Equality of Variances Test		The *t*-Test for Equality of Means						
	F	Significance	t	df	Significance (Two-Tailed)	Average Difference	Standard Error	95% Differences Confidence Interval	
								Lower Limit	Upper Limit
Using Equal Variances	2.428	0.210	−13.219	163	0.000	−0.89419	0.06765	−1.02776	−0.76062
Not using equal Variances			−13.161	151.415	0.000	−0.89419	0.06794	−1.02843	−0.75995

The statistical results showed that the average number of correct questions improved by 3.0327 for Group A students who did not use the digital learning sheets after visiting the exhibition, while the average number of correct questions improved by 3.9269 for Groups B, C, and D students who used the digital learning sheets, which was noticeably higher.

In Table 3, the T test results of the independent samples were presented, in which the F test was significant (F = 0.210 > 0.05), so that the t-value of "equal variance used" = −13.219, the negative value of which indicates that the average of group A is lower than that of groups B, C, and D. The significance of the two groups reached a significant level of 0.000. In other words, the overall effect of using the digital learning sheets during the exhibition visit significantly improved the learning outcomes of the students, compared to the learning outcomes of those who did not use the digital learning sheets.

4.2.3. Research Hypothesis 3: "Learning Motivation" Has a Significant and Positive Effect on "Learning Outcomes" with or without the Use of Digital Learning Sheets

The third hypothesis was to examine the relationship between "learning motivation" and "learning outcomes", whether there is a positive relationship between learning motivation and learning outcomes for the overall visitation behavior with or without the use of learning sheets.

In this section, the Pearson correlation coefficient was used to compare the mean relationship between the two factors. The results showed a significant positive correlation between "learning motivation" and "learning outcomes", with a significance of 0.000 and a correlation coefficient of 0.404, indicating a moderate correlation between the two factors. It also confirms research hypothesis 3: "Regardless of the use of digital learning sheets or not, 'learning motivation' has a significant and positive impact on 'learning outcomes'. Besides the above-mentioned relationship between the two, the statistical results indicated that the "Exhibition of Taiwan's Woodcrafts" could provide a certain degree of education through the content of exhibition planning, exhibition information, display effect, exhibits of items and service flow, and promote the learning motivation and effectiveness of the visitors.

4.2.4. Research Hypothesis 4: There Is a Significant Difference in the Effect of Different "Digital Learning Sheet Design Strategies" on "Learning Motivation"

In Hypothesis 4, the study examined whether the digital learning sheets designed with different design strategies had varied effects on the "learning motivation" of the students who visited the exhibition. This will help future exhibition curators, learners and designers, as well as formal and informal educators in their design and educational activities, as a reference for their practical experience. This study was conducted by one-way ANOVA with post hoc comparisons using the Scheffe method.

It was found that the three different types of digital learning sheets would have a significant effect on the students' attention, with a significance of 0.000 (Table 4). In this study, a post-comparison using the Scheffe method showed that there was a significant

difference between the mean number of Attentions obtained from the three different learning sheets, with Group B having the highest mean among the three groups (Table 4), which means that the digital learning sheets designed with the "sensory and exploration design approach" would promote the highest Attentions among the children.

Table 4. Post hoc comparisons of the ARCS variance analysis for the four groups of B, C, and D students (Scheffe).

Post Hoc Comparisons of the Attention Variance Analysis of Students in Groups B, C, and D				
Group	N	Alpha = 0.05 Subset		
		1	2	3
B Group	84	3.8214		
C Group	77		3.4221	
D Group	75			2.9933
Significance		1.000	1.000	1.000
Post Hoc Comparisons of the Relevance Variance Analysis for Students in Groups B, C, and D				
Group	N	alpha = 0.05 Subset		
		1	2	
B Group	84	3.7589		
C Group	77		3.4643	
D Group	75		3.3533	
Significance		1.000	0.317	
Post Hoc Comparisons of the Confidence Variance Analysis for Students in Groups B, C, and D				
Group	N	alpha = 0.05 Subset		
		1	2	
B Group	84	3.7946		
C Group	77	3.711	3.711	
D Group	75		3.5733	
Significance		1.000	0.534	
Post Hoc Comparison of the Analysis of Satisfaction Variance among Students in Groups B, C, and D				
Group	N	alpha = 0.05 Subset		
		1	2	
B Group	84	3.872		
C Group	77		3.6461	
D Group	75		3.6233	
Significance		1.000	0.903	

Further comparison with the Scheffe method showed that the mean of Group B was significantly higher than that of Groups C and D among the three different learning lists, while there was no significant difference between Groups C and D in statistical analysis. Examining the impact of the three different types of digital learning sheets on students' Relevance, the results showed an equally significant impact, with a significance of 0.000 (Table 4).

Further examining the effects of the three different types of digital learning sheets on students' Confidence, statistical analysis revealed that the three different types of digital learning sheets resulted in a significant difference in students' Confidence, with a

significance of 0.015. After a comparison of the Scheffe method, there was a significant difference between Group B and Group D. The mean Confidence feedback for Group B was 3.79, which was significantly higher than the mean of Group D, which was 3.57 (Table 4).

Finally, the study examined the effects of the three different types of digital learning sheets on the students' Satisfaction, and the statistical result reached a significant level of 0.000. A post hoc comparison in the Scheffe method revealed that the mean Satisfaction feedback of the students who used the "sensory and exploration design approach" digital learning sheet was significantly higher than the other two groups. (Table 4)

In summary, when students in groups B, C, and D used digital learning sheets designed with different learning sheet design strategies while visiting the exhibition, they were motivated to learn at different levels and their impact was highly significant. That is, research hypothesis 4 that "there is a significant difference in the effect of different "digital learning sheet design strategies" on "learning motivation", is valid.

From the analysis of the four aspects of learning motivation, namely, Attention, Relevance, Confidence, and Satisfaction, the digital learning sheets designed according to the "sensory and exploration design approach" were more effective than the other two groups of students. Therefore, it can be inferred that Taiwanese students aged 11 to 15 appeared to be more motivated to participate in the exhibition through sensory experience and exploration, whether by exhibiting objects in an interactive format or by using learning sheets to guide them to use their senses to work on, experience, experiment, and examine the exhibition content.

In contrast, the study also observed that among the three different strategies for designing the digital learning sheets, the lowest motivation feedback was found among Group D students who used the digital learning sheets' "design approach of discussion, analyzation, integrated comparison and commentary". The reason could be explained by the fact that in Taiwan's traditional elementary and junior high school education, it is more common to see teachers giving lectures unilaterally, which is criticized by the education sector in Taiwan as a "fill-in-the-duck teaching method". As a result, students do not have sufficient opportunities to discuss, evaluate, discuss, and synthesize issues during their school learning. In the course of this study, it was observed that at least half of the students were afraid to express their opinions during group activities due to timidity, shyness, or concern for the judgment of others and peers. The students in Group D were unable to focus their minds on the learning of the knowledge domain and were more concerned with social issues, resulting in lower motivation than the other two groups.

4.2.5. Research Hypothesis 5: There Is a Significant Difference in the Impact of Different "Digital Learning Sheet Design Strategies" on "Learning Outcomes"

In Hypothesis 5, the study examines whether different digital learning strategies have a significant impact on the learning outcomes of the children who visit the exhibition, and the three dimensions of Cognitive, Affective, and Psychomotor are examined, respectively. The marking system for "learning outcomes" was also based on the number of correct questions in the "post-test questionnaire" compared to the "pre-test questionnaire".

Based on the results of the analysis of variance, it was found that the different design strategies of the digital learning sheets significantly affected the learning effectiveness of the Cognitive component, with a significance of 0.010. From the post hoc Scheffe method comparison, the mean number of correct answers on the Cognitive section was 4.27 for Group B, which was significantly higher than the mean number of correct answers on the Cognitive section of 3.86 for Group C (Table 5).

Next, the results of the analysis of variance showed that there was no significant difference in the mean number of correct answers for the Affective section among the students using different digital learning sheets, with a significance of 0.466. The mean number of correct answers for Groups B, C, and D, respectively, was 3.83 for Group B, 3.99 for Group C, and 3.95 for Group D. The statistical results show the significance that

different strategies for designing the digital learning sheets do not produce significant differences in the Affective of learning outcomes.

Table 5. Post hoc comparison of the Cognitive and Psychomotor variance analysis of students in groups B, C, and D (Scheffe).

Post Hoc Comparison of Cognitive Variance Analysis of Students in Groups B, C, and D			
Group	N	Alpha = 0.05 Subset	
		1	2
B Group	84	4.27	
C Group	75	4.12	4.12
D Group	77		3.86
Significance		0.538	0.165
Post Hoc Comparisons of Psychomotor Variance Analysis for Students in Groups B, C, and D			
Group	N	Alpha = 0.05 Subset	
		1	2
B Group	84	4.11	
C Group	75		3.57
D Group	77		3.57
Significance		1.000	1.000

Finally, regarding the Psychomotor component of learning outcomes, the results of the analysis of variance showed that the three different digital learning sheets significantly affected the Psychomotor learning outcomes of the students with a significance of 0.000 (Table 5). The results of this study, which were further compared using the Scheffe method, showed that Group B students who used the "principle of sensory exploration of physical objects" digital learning sheet had significantly higher Psychomotor learning outcomes than the other two groups (Table 5).

Summing up the results of the above study, research hypothesis 5, which is that "there is a significant difference in the impact of 'different digital learning design strategies' on 'learning outcomes'" is partially valid. In addition to the Affective learning outcomes, the cognitive and psychomotor learning outcomes were better for children who used the Design Principles for Sensory Exploration of Objects (Group B) digital learning sheet. We concluded that interactive learning through sensory experiences in exhibitions for students aged 11 to 15 years in Taiwan could create better comprehension and memory outcomes for students. This result echoes the view of Kimche [52], the former executive president of the American Association of Science and Technology Centers, that the most effective way to learn is for people to explore things that interest them in a personal and experiential way. Therefore, the museums could consider providing visitors with effective learning experiences, sensory exploration, group cooperative learning, and interpersonal intelligence development [53]. This study result would be beneficial in promoting learning attitudes and effectiveness, and such results could serve as an important reference for future exhibition planning and learning sheet design.

5. Conclusions and Suggestions

As a provider of informal education, museums play a critical role in the lifelong education of society. It is important to know that the operation of regional museums is to consider ways to revitalize local industries, promote the artistic life of residents, assist in the development of education, and even more importantly, provide a place with the functions of tourism, leisure, entertainment, and education.

A quality themed exhibition provides the community with ample opportunities for knowledge learning. This study attempts to provide comprehensive empirical research of the design of digital learning sheets for museum exhibitions. Therefore, the learning sheet design approach, proposed by museum curator Hooper-Greenhill, is adopted as the foundation. Digital technology has been applied to integrate more interactive, extended reading, and fun possibilities into the design of three digital learning sheets.

This study chose the "Exhibition of Taiwan's Woodcrafts", which was organized by the National Taiwan Craft Research and Development Institute (NTCRI), as a case study to examine whether the use of different types of digital learning sheets had a significant impact on the "learning motivation" and "learning outcomes" of the students when they visited the exhibition. The study results are promising. In the study, we found that for Taiwanese students, the benefits of the digital learning sheets designed using the "sensory and exploration design approach" were better than those of the other two groups in terms of motivation and learning outcomes. The study concluded that the digital learning sheets designed with the "sensory and exploration design approach" could guide the students to engage actively in the context of the exhibition. Such a design strategy encourages the use of different senses, such as sight, smell, and touch, to deepen the memory of the exhibition content. This is the main reason why we believe that the digital learning sheets designed with the "sensory and exploration design approach" can lead to the best learning outcomes for the learners. The results will contribute significant references for future curatorial teams as well as for digital learning unit designers and educators in their design and educational implementation. In addition, this study also reminds us that in both formal and informal education contexts, the teaching strategies implemented by the educators must be more in line with the learning styles and patterns of the students in order to achieve better learning outcomes.

Finally, digital learning is a rising future trend. However, the use of digital learning in museums remains rare. We believe that digitization, convenience, and interactivity are the development directions and are a necessity for future lifestyles. This study focuses mainly on the digital learning sheet design strategies of museum exhibitions, and it also adopted quantitative questionnaires to examine the effectiveness of learning. Nevertheless, this study still offers directions for future studies to explore the various possibilities of digital learnings in museums and a possibility for further research in a more in-depth qualitative research approach. We hope that the study result might as well contribute to the digital transformation of museums so that there might be more possibilities of museums in providing diversified services in exhibitions, education, and learning.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Pre-Test and Post-Test Questionnaires (The Implementation Is in the Chinese Version)

- Pre-test Questionnaires

Class : _____Name : _____Date : _____

Welcome, students!
We are about to visit "Into The Woods - An Exhibition of Taiwan's Woodcrafts" presented by the National Taiwan Craft Research and Development Institute. Do some of you have some knowledge about Taiwan's wood products, tools, and artworks?
We would like to ask you to answer some questions first, so that we know what you expect from the exhibition.
Please try to answer them in detail.

Part 1

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. I'm excited to visit the exhibition later on.	☐	☐	☐	☐	☐
2. There are plenty of things to check out in the exhibit later that I want to see in detail.	☐	☐	☐	☐	☐
3. Before coming to see the exhibition, I purposely went to read the books on wood first.	☐	☐	☐	☐	☐
4. I think the content of the exhibition may be important to me.	☐	☐	☐	☐	☐
5. I will learn much knowledge that I can apply in my daily life from the exhibition lectures.	☐	☐	☐	☐	☐
6. I usually do a good job of environmental protection.	☐	☐	☐	☐	☐
7. I can name at least five kinds of trees	☐	☐	☐	☐	☐
8. I would like to pay more attention to the issue of wood recycling after watching the exhibition	☐	☐	☐	☐	☐
9. I know what can be made from wood.	☐	☐	☐	☐	☐
10. After the exhibition, I think I will read more books about wood.	☐	☐	☐	☐	☐
11. After seeing the exhibition, I think I would like to know what else is made of wood	☐	☐	☐	☐	☐
12. After seeing the exhibition, I think I will like the nature subjects more.	☐	☐	☐	☐	☐

Part 2

1. ( ) When did Taiwan's earliest forestry industry begin to develop? ? (1) Ming Dynasty (2)Qing Dynasty (3) The Japanese Rule Era (4) Early Republic of China Era
2. ( ) Which of the following does not belong to the 5R ecological cycle of national production materials ? (1)Reduce (2)Reuse (3)Redesign (4)Recovery
3. ( ) What is the average altitude of broad-leaved forest? (1) Below 500m (2) 500-2000m (3) 2000-3500m(4)3500 公尺以上
4. ( ) Which of these is recyclable? (1) Wooden furniture (2)Wood Toys (3)Wooden Chair (4) None of the above can be recycled
5. ( ) I know what are made of wood ? (1)Wood Block (2)Guitar (3)Xylophone (4)All of the above answeres.
6. ( ) What are the benefits of man-made forests? ? (1) Reduces pests and diseases (2) Reduces earthquakes (3) Allowing diversity of creatures to live inside (4) Reduces carbon footprint in the production of wood products
7. ( ) If you want to combine the wood, and not using the nail and gluing method, what is this technique called? (1)Bridle Joint (2) Engraving (3) Merging (4) Frame set
8. ( ) Which of the following does the logo in Figure(1) belong to?
(1) Traceable Agricultural Products
(2) Certified Agricultural Standards (CAS) certification
(3) Forest products production traceability barcode (4) Domestic Timber Mark

Figure 1.

9. ( ) If I were to make a percussion instrument out of wood, what characteristics would I look for in wood first? (1) Price (2) Processing (3) Firmness (4) Wood age

- Post-test Questionnaire

Class : _____Name : _____Date : _____

Hello, students!
After visiting the exhibition"Into The Woods - An Exhibition of Taiwan's Woodcrafts" presented by the National Taiwan Craft Research and Development Institute," do you have a better understanding of Taiwan's wood, woodworking tools, techniques, as well as household items and artworks?
We would like to ask you to answer some questions to let us know what you have learned about the exhibition and what you have learned from it.
So, please answer them in detail! After answering all the questions, we have a small gift for you!

Part 1

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. I think the exhibition content is novel and interesting to me	☐	☐	☐	☐	☐
2. There were many things in the exhibition that I found that would make me want to go and see it in detail.	☐	☐	☐	☐	☐
3. I have concentrated on seeing what is on display in each place.	☐	☐	☐	☐	☐
4. After the exhibition, I will want to learn more about it after I go home.	☐	☐	☐	☐	☐
5. I think the content of the exhibition is what I have learned in school.	☐	☐	☐	☐	☐
6. I don't think the content of the exhibition has anything to do with my everyday life.	☐	☐	☐	☐	☐
7. I think most of the things mentioned in the exhibition can be applied in life.	☐	☐	☐	☐	☐
8. After the exhibition, I felt more concerned about the importance of environmental protection.	☐	☐	☐	☐	☐
9. After the exhibition, it does not inform me of the characteristics of different woods.	☐	☐	☐	☐	☐
10. After the exhibition, it makes me pay more attention to the issue of wood recycling.	☐	☐	☐	☐	☐
11. After the exhibition, it reminds me to know which products in my life are made of domestic wood.	☐	☐	☐	☐	☐
12. After the exhibition, it enables me to know more about the types of trees	☐	☐	☐	☐	☐
13. After seeing the exhibition, I feel that I have learned something	☐	☐	☐	☐	☐
14. After the exhibition, I realized that wood can be used to produce various items.	☐	☐	☐	☐	☐
15. After the exhibition, I imagine what else can be done with wood. Such as : _____	☐	☐	☐	☐	☐
16. Overall, I believe it was quite fruitful to see this exhibition today	☐	☐	☐	☐	☐

Part 2

1. ( ) What has happened to Taiwan's timber industry as the United Nations passed the Convention on Biological Diversity? (1) Products cannot be exported, (2) Wooden furniture is becoming increasingly popular, (3) Consumers do not like to use wooden products, (4) Taiwan's timber industry has declined.
2. ( ) Which of the following does not belong to the 5R ecological cycle of national production materials ? (1)Reduce (2)Reuse (3)Redesign (4)Recovery
3. ( ) Why is it that woods of the same size can have different weights? (1) different density due to growth altitude, (2) jerry-building, (3) some have been exposed to the sun, (4) scale inaccuracy
4. ( ) When did Taiwan's earliest forestry industry begin to develop? ? (1) Ming Dynasty (2)Qing Dynasty (3) The Japanese Rule Era (4) Early Republic of China Era
5. ( ) Which of these trees grows at an altitude of 2,000 meters? (1) Taiwan White Fir, (2) Japanese Cedar, (3) Taiwan Acacia, (4) Moso bamboo
6. ( ) Which of the following cultural contexts is the most appropriate for the use of wooden furniture and objects? (1) Music appreciation, (2) Tea tasting space, (3) Floral appreciation atmosphere, (4) All of the above
7. ( ) With the concept of "green consumption", how would it be beneficial? (1) Environmentally friendly, (2) Durable products, (3) Cheaper prices, (4) Artistic legacye
8. ( ) Which of the following themes is not the objective of this exhibition? (1) The tools of livelihood, (2) the sustainability of ecology, (3) the way of living, and (4) the philosophy of life
9. ( ) Why do we need to rethink the use of domestic timber? (1) Maintaining sustainable use of resources, (2) Abundant forest resources in Taiwan, (3) Promoting development of forest industry, (4) All of the above
10. ( ) What are the characteristics of the President's table known as the "Root Table"?(1) the use of twelve local materials, (2) the use of beech wood to express " achievement of excellence", (3) the carving of Taiwan Lily, (4) all of the above
11. ( ) There were many pieces of furniture that could be joined very securely without the use of nails and glue so what is this technique called? (1) tenon jointing, (2) engraving, (3) merging, (4) framing
12. ( ) Which of the following musical instruments can be made of wood? (1) Ukulele, (2) Violin, (3) Xylophone, (4) All of the above
13. ( ) The logo in Figure (1) belongs to which of the following?
(1) Traceable Agricultural Products (2) Certified Agricultural Standards (CAS) certification (3) Forest products production traceability barcode (4) Domestic Timber Mark

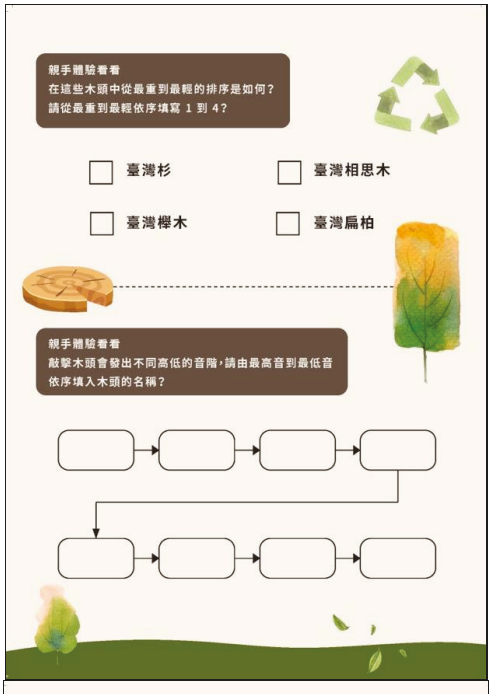
Figure 1.

14. ( ) If I were to make a percussion instrument out of wood, what characteristics would I look for in wood first? (1) Price (2) Processing (3) Firmness (4) Wood age

15. ( ) Which tool do you think is used to make the leaf petals of the flower so thin in Figure (2)? (1) carving knife, (2) wood saw, (3) planer, (4) chisel

Figure 2.

Appendix B. Sensory and Exploration Design Approach Learning Sheet (B Group)


親手體驗看看
在這些木頭中從最重到最輕的排序是如何？
請從最重到最輕依序填寫 1 到 4？
臺灣杉
臺灣相思木
臺灣櫸木
臺灣扁柏
親手體驗看看
敲擊木頭會發出不同高低的音階，請由最高音到最低音
依序填入木頭的名稱？


針對不同海拔高度，請分別寫下二種樹木種類名稱？
請將你的分享寫下來
2000m
針葉林
1500m
闊葉林
500m
熱帶季風林
請勾選哪一個海拔中，擁有臺灣80%以上的物種？
請將他勾選起來
2000m
針葉林
1500m
闊葉林
500m
熱帶季風林
請你到材質實驗室找體驗看看
請問你發現哪一個海拔的木材，敲起來的音調會是最高的呢？
請將他勾選起來
2000m
針葉林
1500m
闊葉林
500m
熱帶季風林
光臘樹
烏心石
桃花心木
苦楝
臺灣相思木
香杉
臺灣杉
臺灣紅檜


請你紀錄看看
在三樓和四樓的生活物品，可以被分成幾個種類？
請將他們寫下，例如：傢俱、玩具、藝術品...
如果有超過六類，也可以寫在格子以外的地方唷~
請你觀察看看
在三樓和四樓的生活物品，哪一個作品製作上是最花時間？
哪一個作品製作上複雜？
請把作品的名字寫下來
請你觀察看看
在三樓和四樓的生活物品，哪一個作品在製作時需要用到的木材
體積會是最大的呢？
請把作品的名字寫下來


這裡介紹的三種不同的標章，分別稱為甚麼名稱？
請將他們寫下來。
哪一個標章可以被視為木材的身分證？請將他們勾選起來
台灣木材
TAIWAN WOOD
在臺灣，是由哪一個單位努力建立國內林產業的品牌形象？
請將他勾選起來
林務局
農會
環保署
你是否觀察過家具的木頭是否有甚麼不同呢？
一般可以分為實木、夾心版、木心板、密集板、合成版
其中實木板材是由樹材直接剖片裁切或再組合使用，在今天的展覽中，
有哪些作品是用原木或原木板材製作而成的呢？
請至少找到兩個
實木板

Appendix C. "Design Approach of Memorization, Comparison, and Integrated Association" (Group C)

你有沒有到哪裡爬山過呢？
你覺得你爬山所看到的是天然林？還是人工林呢？
為什麼？
請將你的分享寫下來

你記憶中天然林的樣子，有甚麼特別的地方呢？
請將他們勾選起來


天然林中可以讓我們看到許多種類的樹木


天然林中可以讓我們看到許多種類的生物


可以看到整齊且種類一致的樹木區域


人們喜歡到自然環境散步探索吸收芬多精

在平常的生活中，有哪些生活用品和家具，有用到榫接的技巧做出來的？請將他們勾選起來






在你平常在玩的玩具裡面，有沒有哪些是用到榫接的技巧做出來的？請將你的分享寫下來

木頭和植物都有自己的味道，請你聞看看不同的木頭味道，你曾經有在哪裡聞過這些味道嗎？
請將你的分享寫下來

不同的木頭敲擊起來會有不同的聲音，你過去生活中看過甚麼物品，也是利用木頭敲擊出不同聲音所做出來的？請將他們勾選起來


木魚


響板


木吉他


法官木槌


木琴


竹琴

油桐花通常在春季 3~5 月開花，風一吹來油桐花翩翩飛舞，又被稱為「五月雪」，請你找看看，油桐樹成長在哪一個海拔呢？
請將他勾選起來

2000m 針葉林

1500m 闊葉林

500m 熱帶季風林

小陳同學最喜歡喝阿媽煮的麻竹筍排骨湯，你知道麻竹筍通常成長的海拔高度在哪裡嗎？請將他勾選起來

2000m 針葉林

1500m 闊葉林

500m 熱帶季風林

請你回想看看
在三樓和四樓的生活物品中，哪一些通常會用「聞起來有香味」的木頭呢？請你將物品的名字寫下來

請你回想看看
在三樓和四樓的生活物品中，有沒有哪一些，是你以前沒見過，來到這個展覽才看到的呢？請你將物品的名字寫下來

在生活中你有沒有曾經在哪裡看過 CAS 的認證標標章？
你曾經在哪裡看到？請你將分享寫下來(至少兩項)

你是否觀察過家具的木頭是否有甚麼不同呢？
一般可以分為實木、夾心版、木心板、密集板、塑合版
其中夾心版、木心板、密集板、合成板多會使用膠合方式製成，請問在你的家中是否也有這樣類型的家具呢？請你將分享寫下來


木心板


塑合板

你和你的家人，有沒有自己動手做過木工呢？
是做出了甚麼樣的東西？
你在其中幫忙了甚麼事情呢？請你將分享寫下來

在下列的木工具中，有哪一些工具是你家中有的？請在☐中打叉☒
哪一些工具是家裡沒有的呢？ 請在☐中打叉☒


☐ 木工鐵尺


☐ 鋸子


☐ 木刻刀


☐ 槌子


☐ 鉋刀


☐ 木器漆

Appendix D. "Design Approach of Discussion, Analyzation, Integrated Comparison, and Commentary" (Group D)

木頭和植物都有自己的味道，你覺得這些不一樣的味道，可以被做甚麼生活用品？請將他們勾選起來


木屑香包


樟腦丸


天然蚊香


檀香精油


沉香佛珠


書籍紙張

不同的木頭敲擊起來會有不同的聲音，你覺得這些不一樣的聲音，可以被做甚麼生活用品？
請將你的分享寫下來

不同海拔高度，樹木的葉子也會長得不一樣？
請你連連看，三種海拔高度環境中，分別會有甚麼樣的樹木葉子呢？

2000m 針葉林　1500m 闊葉林　500m 熱帶季風林

請你到材質實驗室找體驗看看
請問你發現哪一個海拔的木材拿起來會是最重的呢？
請將他勾選起來

2000m 針葉林　1500m 闊葉林　500m 熱帶季風林

在生活中保持創意，你也可以是小小發明家唷！
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Article

The Design and Implementation of an Innovative Course on the Creation of Cultural Landscape Images: A Case Study of Dalin Township in Taiwan

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Abstract: Innovative design-based education is a student-centered approach that aims to nurture students' proactivity, creativity, and interdisciplinary integrated skills. The curriculum planning of a course in this study incorporated design-based learning with the 4D design process. Three units were planned: field exploration and concept development, 3D wearable creations, and cultural landscape shaping. Each unit was co-taught by an interdisciplinary teacher. By means of teamwork, the students explored agricultural spaces and cultural stories, then used paper materials and mixed media to create wearable creations. Afterward, they visually recorded their unique views of traditional spaces and created cultural landscape images. To elucidate their learning outcomes and creative expression, this study adopted a mixed-methods approach. The results are as follows: (1) The students experienced positive growth in their five core competencies. Their "field-based knowledge" and "skills and technological value" were significantly improved. (2) The five major perspectives of the students pointed out that creativity stems from multicultural symbols, the learning outside-the-classroom approach reinvigorated motivation, more confidence is gained through learning by doing, teamwork can create more possibilities, and discovering one's other interests is possible through diverse exploratory approaches. (3) The teacher summarized the feasibility of designing and implementing innovative courses under three themes: conversing with methods, conversing with cultures, and conversing with teams.

Keywords: innovative design; design-based learning; 4D design process; creation of cultural landscape images; 3D wearable creations

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1. Introduction

In light of global issues such as low birth rates, population aging, digitalization, and climate change, the best way to surmount the challenges and impacts of these issues is, from an educator's perspective, to change one's instructional mindset and approaches, as this allows for the educator and their students to deepen their interdisciplinary skills, creativity, social compassion, and enthusiasm. Liberal education is the mainstay of education in Taiwan; students achieve the goal of sustainable learning by broadening their interdisciplinary perspectives and understanding, thinking, and constructing values [1]. However, Wu (2019) noted that in practical Taiwanese educational settings characterized by intellectualism, students are likely to achieve excellent personal grades at the expense of teamwork and social compassion [2]. Even though Taiwan's higher education system has fostered highly professional talents in students, they find it difficult, due to a lack of widened perspectives, to strike a balance in the workplace between humanities and technology, and have trouble engaging in teamwork [3]. In addition, classroom learning in Taiwan is mostly centered on conveying knowledge and ideas using content-oriented instructional materials. In this sense, students learn according to the logic of their discipline and acquire decontextualized fragments of knowledge [4]. Students merely acquire "packaged knowledge" at school [5]. Even though this approach allows them to view the knowledge framework rapidly and is conducive to nurturing their professional skills, it omits the essence of "experience and

knowledge-based" learning [6]. When students graduate and encounter complex social problems in real life, they are often unable to overcome these adversities and become easily frustrated.

The goal of education is to safeguard the creativity of every student and enable them to connect their acquired knowledge with the real world based on their experiences [7]. Dewey (1910) stated that the interaction between a person and the environment creates a problematic situation that is conducive to activating students' learning motivation. The best approach to learning is through learning by doing [8], as practice-oriented teaching triggers students' active reflection and thought, facilitating their understanding of the association between matters [9]. The complexity of real-world problems can only be surmounted through interdisciplinary thinking. Design-based learning (DBL) is a novel, interdisciplinary, exploratory, and learner-centered teaching approach that combines design thinking and design practice to create new products, systems, and solutions. This approach also enables students to explore and solve real-life design problems and engage in reflective learning through hands-on experiences [10]. The DBL process emphasizes uncovering new possibilities through interactive methods. Students increase their general and innovative skills while teachers provide guidance and instrumental support to assist them in solving problems or completing a task [11]. IDEO, a design and consulting firm, takes a human-centered design thinking approach to find innovative solutions for various issues. By successfully consolidating commercial value with technology, the firm has created numerous well-known design solutions and triggered innovation in other firms and organizations [12]. The d. school at Stanford University has also introduced design thinking courses that underscore attitudes of humanism, embracing creativity and practical thinking [13]. Liu and Kang (2017) agreed that the curriculum design in DBL should focus on solving complex problems through design thinking. Student teams study special topics with the help of interdisciplinary teacher groups [3]. DBL is a paradigm for interdisciplinary co-teaching and has attracted resource investments from various enterprises.

The university where the researcher teaches is situated on the Chianan Plain in Chiayi County, which is the county with the highest rate of aging population (18.61%) in Taiwan. The Chianan Plain is characterized by severe population aging amidst a rural backdrop. Although the government approved the Rural Rejuvenation Act in 2010 with the hope of promoting rural development and rejuvenation, the greatest barrier is that the future of rural areas remains underemphasized. As a result, younger people are unwilling to venture into rural industries, and even if they were willing, they would still lack the means to do so [14]. Thus, the researcher suggests that knowledge should not only exist in textbooks and lecture notes, and that the learning process should not be confined to classrooms or campuses. An innovative course design gives students the opportunity to be connected with local rural resources.

The aim of this study is the curriculum planning of a course in incorporated design-based learning (DBL) with the Double Diamond (4D) design process. The question of this study are will students complete a design practice through teamwork and hands-on thinking? Additionally, research is used to explore students' learning effects and creative performance, as well as the course participation perspective of teams with excellent overall performance in the course. Finally, the teacher reflected on the feasibility of innovative curriculum design and implementation.

2. Materials and Methods

2.1. Study Design

This study applied the learner-centered learning approach to a practical course. During the learning process, several practical questions were proposed to help the students develop their active learning, critical thinking, and problem-solving skills by engaging in group discussions [15]. The learning process was also aided by multidisciplinary teachers who elicited the students' innovative design skills through teamwork, cooperative learning, and practical communication and design. The curriculum design comprised three instructional

units: field exploration and concept development, 3D wearable creations, and cultural landscape shaping. Each unit had a multidisciplinary teacher who assisted the students to practice identifying the problem and activate their teamwork spirit. The learning process covered observation and exploration, brainstorming, inductive analysis, creative thinking, 3D wearable creations, and outcomes display. For the purpose of elucidating the students' learning outcomes and the changes in their mentality during the creation process, this study employed a mixed6methods research approach. The students' learning outcomes were quantified by means of a core competencies evaluation questionnaire, which was administered to the students as a pre-test at the beginning (week 1) and as a post-test at the end of the course (week 18). The students also completed a teaching feedback survey. The qualitative aspect centered on creation and outcome evaluations and focus group interviews to extract the students' perspectives and after-course reflection on the innovative course design. The study framework is presented in Figure 1.

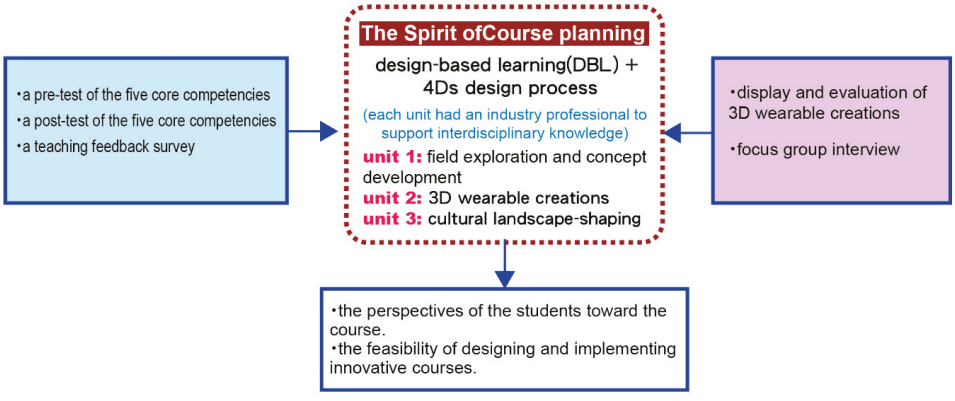


Figure 1. The framework of this study (source: this study).

2.2. Course Planning and Design Procedure

The course is designed to "take students out of the classroom" and view the world from a new perspective, collect insights with an open mind, discover something new, seek inspiration, and develop their opinions about various matters they see. The objective of this course is to enable students to interpret self-created local cultural landscape images by folding paper-based creations crafted according to their own inspirations and imagination. The source of inspiration and imagination is the pictograms of rural spaces around Dalin Township. Lynch (1960) wrote that the city image is the long-term affective connection that every urban dweller has with some parts of the city that they live in, and their image of the city is immersed in memories and full of meaning [16]. An image is a reenactment of a person's previous sensory experiences in their memory [17]; it is a person's subjective perception and experience of information transfer, and a mental representation that shapes perception and feelings. The importance of sensory experience lies within the sensory shaping of perception and the acquisition of cognition. Meaning is formed through the continuous interactions between memory and culture. The dynamic elements in a city, particularly human activities, are as important as the static elements. This is because we are not spectators of urban grandeur, but are rather a part of it, as we share the same stage with others. Lynch suggested that "our perceptions of a city are not sustained, but are fragmentary, partial, and mixed with other matters". In the city, virtually all our senses operate simultaneously and the aggregation of these senses shapes the image of a city. Lynch divided the city image into five overlapping elements: paths, edges, districts, nodes, and landmarks. Districts are organized into nodes, defined by edges, penetrated by paths, and peppered with landmarks [16]. The crisscrossing of these elements constitutes the spatial state of a city and serves as an important reference for the sensory

environments of urban dwellers. The question is, how does the observer interact with the things that they observe? How does the observer interpret and organize the things they see and how much attention do they pay? How does the observer leverage the interactions between the five aforementioned elements to extract and convert the images of old cultural spaces? This study defined the design concept for the creation of imagined cultural landscapes as shown in Figure 2. This concept is rooted in the projection and extension of spaces (including culture, folklore, and objects), followed by the formation of the observed meanings through the randomness of character landscapes, followed by symbol conversion and interpretation based on the integration of composite materials (wearing the paper structures) and digital elements, and subsequently the creation of various storylines about the creators' meanderings through old and new cultural landscapes based on the spatial and routine interactions between the body, vector, and media.

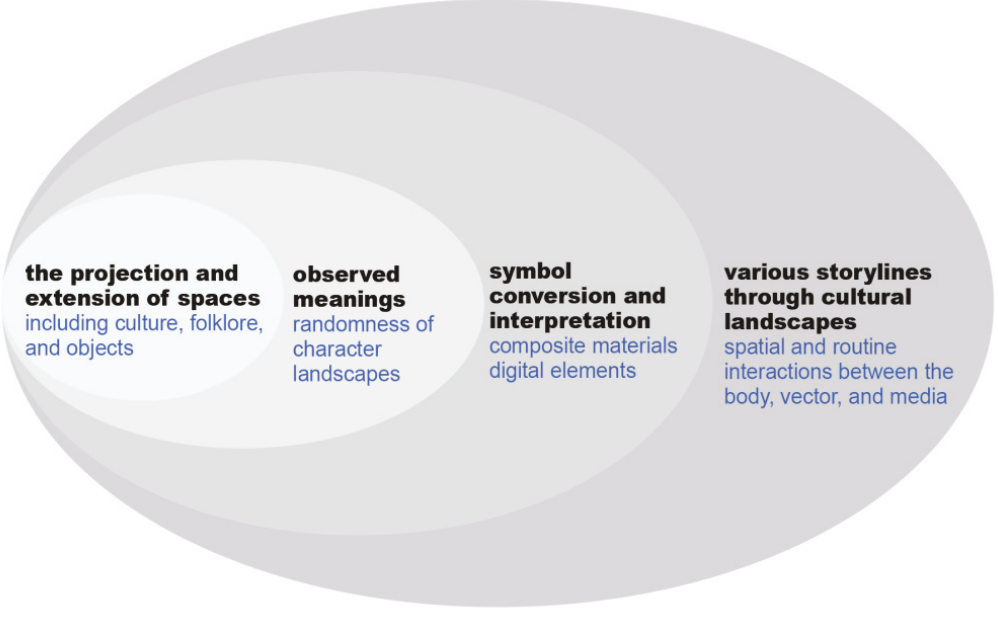


Figure 2. The design concept for the creation of self-created cultural landscape images (source: this study).

To accomplish the aforementioned objectives, the curriculum comprised three instructional units: field exploration and concept development, 3D wearable creations, and cultural landscape shaping. The complex design process in this study covered divergent thinking and convergent thinking, and the study adopted the Double Diamond (4D: discover, define, develop, and deliver) design process model developed by the Design Council (2005) [18] to plan the 18-week course (see Figure 3).

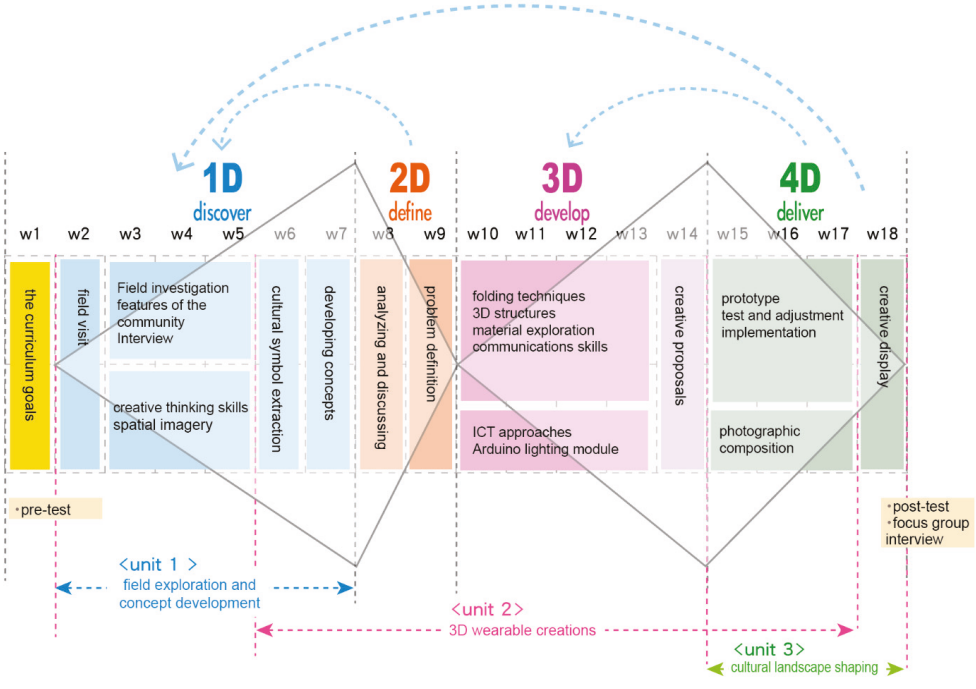


Figure 3. Applying the 4D design process in the curriculum planning of the 18-week course (source: this study).

1. 1D, discover. This stage consists of: describing the curriculum goals, activity contents, problem awareness, and various other topics; organizing on-site surveys to help students understand more about the abundant features of the community (humanistic, cultural, and geographical features, landscapes, and industries) and immerse themselves in the warmth of the spaces, images, and residents of the community; organizing icebreaker activities to train the students' teamwork and creative thinking skills, thus facilitating them in exploring the spatial imagery, extracting cultural symbols, and developing concepts;
2. 2D, design. This stage centers on the meaning of observations by using empathy maps, as well as analyzing, discussing, and defining the meanings of each team's observations;
3. 3D, develop. This stage is about symbol conversion and interpretation. The students participated in multi-perspective creative thinking activities, tested local artistic media, and developed diverse concepts including beginner folding techniques, three-dimensional structures, material exploration, design discussions, communication skills learning, and creative proposals;
4. 4D, deliver. This stage focuses on the students' storylines about their meanderings around Dalin Township. Actual practical outcomes in prototype design, design practice, audiovisual composition, and photographic and creative exhibitions were generated by leveraging the cooperation between the students and the guidance of interdisciplinary teachers (who specialize in field knowledge, ICT approaches, and photographic composition and expression).

2.3. Curriculum Design and Educational Settings

The curriculum design comprised three instructional units, each supported by an industry professional to boost the students' interdisciplinary knowledge.

1. Unit one was supported by Mr. Chiang Ming-he (who gave an 8 h course), who gave guided tours to students of the community's cultural spaces and explained the stories behind the featured attractions and friendly community spaces;
2. Unit two was supported by Mr. Lee Wang-pao (who gave a 4 h course), who specializes in ICT integration and Arduino lighting module creations. The students learned how to connect LED light strips to an Arduino board and make them flash by writing code;
3. Unit three covered photographic composition and photography techniques and was supported by Mr. Wu Ming-shu (who gave a 4 h course). He teaches students the principles of image composition and offers a visual guide to the techniques of photography.

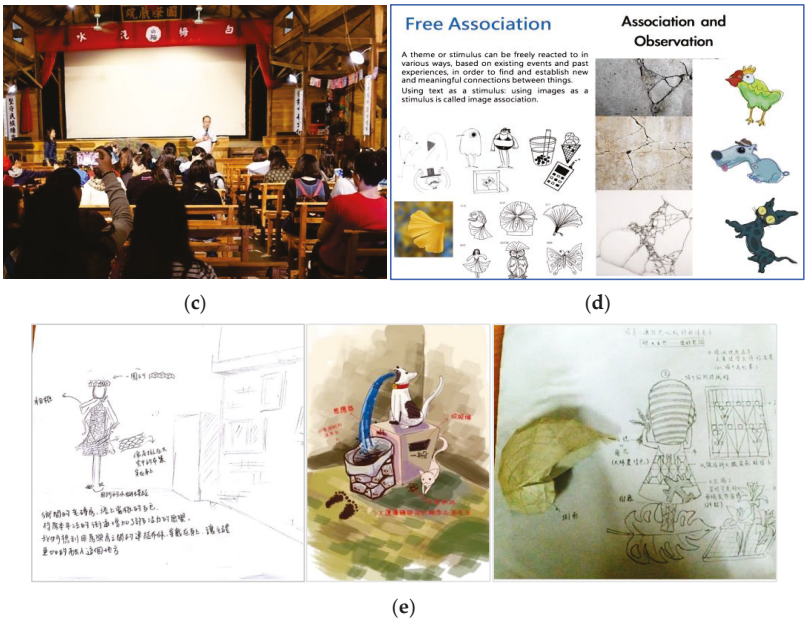
The detailed designs and educational settings of the three instructional units are described as follows.

2.3.1. Field Exploration and Concept Development

The first task in the design process is to understand the essence of the problem [19], which can be discovered through images, forms, textures, colors, sounds, and smells. In this course, the students visited communities to have a practical experience of their rich humanistic, environmental, industrial, and landscape features. Mini getaways were also arranged to help the students discover Dalin's local features and cultural stories. Mr. Chiang himself took the students on a guided tour around Dalin, during which he explained the stories behind the featured attractions and friendly community spaces. The classroom activities consisted of a series of exercises combining creative thinking and cultural elements. The training sessions included topics such as figurative and audio associations, observation and imagination, complexity and simplicity, biomimicry, etc. Through these activities, the students activated their boundless thinking and interacted and discussed with one another to create interesting concept maps. The students were further guided to participate in knowledge construction and exploration experiences during which they fostered their independent thinking skills through visual observation, hands-on experiments, and brainstorming. Their independent thinking skills were a major driving force behind the efforts they invested in the process. The educational settings for this unit are presented in Figure 4.

(**a**) (**b**)

Figure 4. *Cont.*



(**c**) (**d**)

(**e**)

Figure 4. (**a**) Teamwork: ice breaker game; (**b**) Field visit: the miracle of Wusheng Temple; (**c**) Field visit: a traditional old theater brought back to life; (**d**) Training in creative thinking and design methods; (**e**) Extracting cultural symbols and discussing draft conceptualizations (source: this study).

2.3.2. D Wearable Creations

This unit covered the practical creation of three-dimensional structures from their two-dimensional forms through digital handiwork. Jackson (2011) suggested that during the process of folding, designers convert and construct 3D structures from 2D materials and provide unexpected inspiration and food for thought [20]. This course introduced geometric space-folding techniques, whereby a single piece of paper can be transformed into infinite creations and opportunities. Through techniques such as parabolas, kites, duplicating misalignments of symmetrical shapes, and expansion, a piece of paper can be folded using the same patterns into fascinating 3D structures. Then, under the guidance of ICT expert Mr. Lee Wang-pao, the students learned how to connect LED light strips to an Arduino board and make them flash by writing code. In this way, the students broadened their experience of using interactive art applications in their creations. After several weeks of conceptualization, design, discussion, and revision, all the teams gradually created 3D prototypes of their wearable creations based on the spatial conversions of specific cultures. The educational settings for this unit are presented in Figure 5.

2.3.3. Cultural Landscape Shaping

Every soundless image contains a plethora of stories and aesthetics. Zaltman and Coulter (1995) noted that we humans are often unable to fully express our deepest thoughts through speech and text, and instead we convey them through visual representations [21]. Catchings-Castello (2000) found that over 80% of communications do not rely on speech and text, but rather on image-based thoughts [22]. An environment filled with life not only creates distinctive images, but also plays certain social roles, and provides the source material for memories and symbols of collective exchanges [16]. In this curriculum unit, we invited photographer Mr. Wu Ming-shu to teach students the principles of image composition and offer a visual guide to the techniques of photography. The students brought their finished creations to the community and recorded their reinterpretations of

the cultural spatial landscapes around them through modeling language (light, colors, etc., to determine the desired image) and technical language (shutter speed, focal length, etc., to create different photographic effects). The educational settings for this unit are presented in Figure 6.

Figure 5. (**a**) Classroom learning in designing wearable creations; (**b**) Paper-folding techniques: duplicating misalignments of symmetrical shapes; (**c**) ICT co-teaching in interaction design technology; (**d**) Making a LED lighting module; (**e**) Integration of folding techniques for designers with lighting control; (**f**) Various conversational forms of the wearable creations (source: this study).

(**a**) (**b**)

Figure 6. (**a**) Teaching how to display wearable creations and image demonstrations; (**b**) Teaching photography skills and photographic compositions.

2.4. Study Participants and Settings

The participants of this study were 21 sophomore visual art majors (5 males, 16 females, 19–22 years old, in-person classes 2 h a week for 18 weeks) who took an elective course titled "Introduction to Design". During the course, the students visited Dalin Township in person. Dalin means "the land of verdant forests", but the forests have now been replaced by vast paddy fields. As a typical agricultural township, Dalin enjoys abundant harvests all year round. Even though it is just a small town on the Chianan Plain, the establishment of the Dalin Sugar Factory during the Japanese occupation period was the embodiment of the town's booming industry. Additionally, during the 1950s–1960s, there were two major military camps in Dalin (Zhongkeng and Qiding), which remain in the memories of many men who were stationed there. At that time, Dalin was a thriving entertainment hub, with establishments such as the Xue Xiang Ting Restaurant and the Wang Guo Cinema, bearing witness to the bygone days of prosperity and jubilance. Nowadays, Dalin's heydays are over, and the town is impacted by population migration and aging. However, its hospitality remains unwavering, and the residents' enthusiasm toward other people, and all sorts of objects, as well as to their hometown, is still strong. The students developed storylines about their meanderings around Dalin Township based on the aforementioned traditional elements and through deeper cultural exploration and imagination.

2.5. Study Instruments

2.5.1. Quantitative Instruments

1. Student core competencies scale

The student core competencies scale developed in this study was adapted from the interdisciplinary integration-based core competencies scale [23]. The scale comprised 35 items across five core competency indicators that were revised in accordance with the study objectives (see Appendix A). The five core competencies were: "team communication" (seven items), "implementation" (six items), "field-based knowledge and skills" (six items), "technological value" (six items), and "reflection" (ten items). All items were measured on a five-point Likert scale (ranging from strongly disagree to strongly agree). The scale was administered as a pre-test in the first week of the course and as a post-test in the 18th week. In addition, because the number of students taking the course is less than 30, a small sample of nonparametric tests is used for data analysis (this study uses the Wilcoxon Signed Ranked Test [24]) to understand the course pre-test and post-test differences.

2. Course feedback survey

After the course had concluded at the end of the semester, the students had to complete a 13-item course feedback survey that was designed by the university administration (see Appendix B). Nine items pertained to the students' perceptions about the teachers' preparedness, professionalism, and attitudes during the course, while four items pertained

to the students' own learning attitudes. All items were measured on a five-point Likert scale. Additionally, one item can be free to fill in the open opinions.

2.5.2. Qualitative Instruments

1. Display and evaluation of 3D wearable creations

The evaluation criteria and score weighting of the wearable creations are shown in Table 1. The criteria were the overall performance of the creations (concept, aesthetics, and innovative thinking), which accounted for 70%, the application of technology, which accounted for 10%, and teamwork, which accounted for 20%. The evaluation process was jointly carried out by the teacher and the three co-instructors.

Table 1. Criteria for the end-of-semester evaluation of the wearable creations.

Team Member					
Title					
Creative Concept					
Evaluation Items	**Overall Performance (70%)**			**Technology (10%)**	**Teamwork (20%)**
	Concept (20%)	**Aesthetics (20%)**	**Innovative Thinking (30%)**		
Description	The appropriateness of a creation with respect to the definition of the problem and the subjectivity if conversing with urban spaces.	The overall aesthetics that constitute the shapes, colors, artistic expression methods of the wearable creations' shapes, colors, and expression skills.	The conceptualization of the creations as well as the means of conversion, interpretation, and expression, and the ability to demonstrate a unique and innovative imagination of the cultural landscapes.	The originality and appropriateness of applying technology when creating wearable creations, as well as the completeness of the audiovisual storylines.	The communication within team members and their rapport during the creation process.
Score					
Total Score					
Comment					

2. Focus group interview records

DBL emphasizes learners' autonomous learning after facing problems. Correcting and constructing knowledge in the continuous learning experience, finding solutions, and obtaining practice are also important. Additionally, this study aimed to understand the various views of team members who performed better overall when participating in this innovative curriculum design. Therefore, we will invite the top three teams with the best overall performance after 18 weeks to engage in semi-structured focus group interviews. Each interview lasted for 60 to 90 min and focused on the underlying context of the students' creations, the students' attitudes toward the course, their opinions on teamwork, and their personal views (see Appendix C for the interview outline). The reason for employing the focus group interview approach was to allow team members to interact with one another freely in small groups of three to five. Since everyone had cooperated and performed tasks alongside each other, they could elaborate more freely about their overall learning experience, situation, feelings, and opinions toward group interactions when asked open-ended questions. The host of the interview (the researcher) played the role of asking questions, listening, and maintaining the order of the interview process, as

well as ensuring that everyone had a chance to speak. The entire interviews were recorded in audio, transcribed, and then coded.

3. Results

3.1. Student Core Competencies Scale Results

Figure 7 shows the total pre-test and post-test mean values of the five core competencies of "team communication", "implementation", "field-based knowledge and skills", "technological value", and "reflection". The results indicated that the students had positive growth in all five competencies. Furthermore, the pre-test and post-test, which use the Wilcoxon signed ranked test (see Table 2), revealed that the level of significance of the students' "field-based knowledge ($z = -2.987$, $p = 0.003$)" and "skills and technological value ($z = -2.192$, $p = 0.028$)", with a significant value as $p < 0.05$. This indicates that after participating in the course, the students significantly improved their "field-based knowledge" and "skills and technological value".

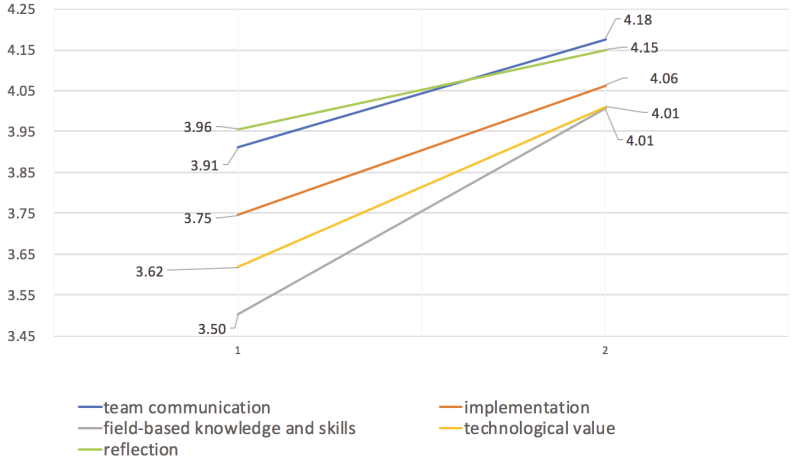


Figure 7. Pre-post-test analysis of the five core competencies (source: this study).

Table 2. Pre-post-test of the Wilcoxon signed ranked test results.

	Negative Ranks			Positive Ranks			Test Statistics		
	n	Mean Rank	Sum of Ranks	*n*	Mean Rank	Sum of Ranks	Ties	Z	*p*
Team communication (post-pre)	6	7.58	45.50	12	10.46	125.50	3	−1.747 [b]	0.081
Implementation (post-pre)	6	10.33	62.00	14	10.57	148.00	1	−1.610 [b]	0.107
Field-based knowledge (post-pre)	3	10.00	30.00	18	11.17	201.00	0	−2.987 [b]	0.003 *
Technological value (post-pre)	5	7.10	35.50	13	10.42	135.50	3	−2.192 [b]	0.028 *
Reflection (post-pre)	7	9.79	68.50	12	10.13	121.50	2	−1.068 [b]	0.286

* $p < 0.05$; [b] Based on negative ranks.

3.2. Course Feedback Survey Results

The results of the students' 13-item course feedback survey. The overall satisfaction was 4.44 (standard deviation = 0.66), indicating that the course received a strong and favorable reception from the students. Additionally, the students gave substantial positive feedback for the course in the open opinions on the last question of the questionnaire, such as:

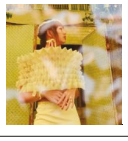
The teacher pays attention to our study (student 1). She is a very serious and friendly teacher (student 2). I think I have learned a lot (student 4). The teacher is really hardworking in class, showing us a lot of work, guiding us really hard, and giving us a lot of new stimuli (student 7). The teacher was very thoughtful and asked us to go to Dalin to do local cultural connection creation (student 11). I hope to have more time to do it next time (student 12). The creation combines old and new elements and creates unique ideas and finished products, and because of the combination of local customs, the whole event has a strong human touch (student 17). Although I feel tired during the creation period, the sense of accomplishment at the moment of making the work is full of emotions (student 19). Very happy with the finished product (student 20).

3.3. Displaying the Wearable Creations

Figure 8 shows the students displaying their creations of cultural landscape images. The researcher and the three interdisciplinary teachers co-evaluated the creations, and the results are shown in Table 3.

Figure 8. The seven teams wearing their creations on the 18th week of the course (source: this study).

Table 3. Evaluation results of 7 groups of end-of-term wearing works.

No	A	B	C	D	E	F	G
Works							
Team name	Do you remember you?	Jingle bells	Elves	Migration	Bless and light	Slow city slow travel	Time machine
S1	64	65	61	67	66.5	60	58
S2	6	8	7	8	8.5	6.5	6.5
S3	17	18	17	19	17	15.5	15.5
Sum	87	91	85	94	92	82	80

S1: overall performance of the work (70%); S2: technology application (10%); S3: teamwork (20%); Sum: total score.

The three winning teams were team D "Migration", team E "Bless and light", and team B "Jingle bells". The teams discussed their creations and then consolidated them into a storyline titled "Hi Dalin! A conversation with slow-paced life" (The order of presentation of the three groups of works: team D-team B-team E).

Wandering around Dalin at a slow pace.
The bygone era of the town is rooted in its serenity,
the flowers bloom and wither, the times change, yet the one thing that remains is Dalin's distinctive warmth.
Those who migrated away return to their hometown and recollect the fond memories of their childhood.
The residents express gratitude to the gods for blessing them all year round.

1. Migration (team members: You Songlin, Wang Yixin, Shi Huiwu, Chen Yaqi, Liao Chuying)

Wandering around Dalin at a slow pace. Dalin is renowned for being a "slow city" and has unhurried and genial beauty. We used snails and migratory fish to symbolize a person's return to their hometown and to showcase the traditional features and wonders of Dalin. We take you on a tour of Dalin's incomparable traditional serenity. Here, roots begin to grow on an unassuming plot of land, and then flowers begin to bloom. From generation to generation, the antiquated and natural ambiance of the town awaits our senses (see Figure 9).

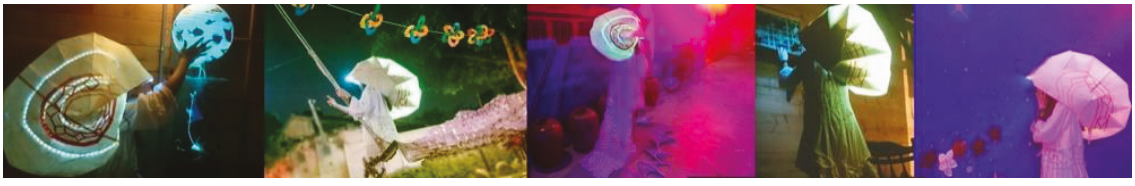


Figure 9. Images of team D's wearable creation themed "Migration" (source: this study).

2. Jingle bells (team members: Li Kaili, Luo Peiyun, Lin Lian, Zhang Jiayu)

Returning home and reminiscing about childhood. We transformed into "jingle fairies" who wander around the city. The fairies' style of carrying an umbrella and a mock water heater is inspired by the old ceramic tiles found in the streets and alleyways of Dalin (in days of yore, Taiwanese bathtubs were often furnished with decorative tiles). The ceramic tiles decorated on the transparent raincoat and the paper-folded water splashes on the umbrella are depictions of a fairy returning to its hometown in search of the subtle beauties within (see Figure 10).

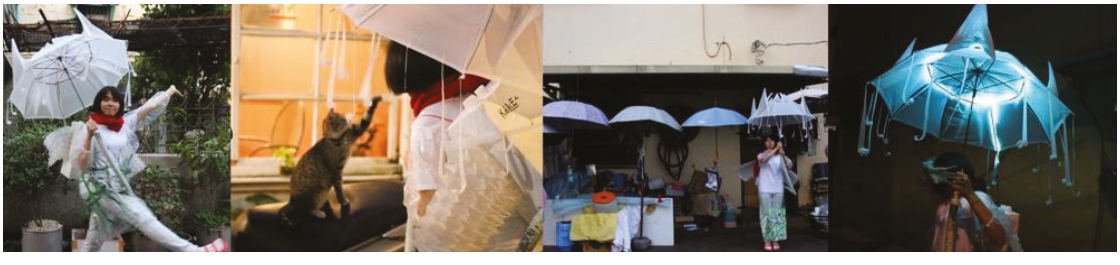


Figure 10. Images of team B's wearable creation themed "Jingle Bells" (source: this study).

3. Bless and light (team members: Wu Zhixian, Song Peirong, Zheng Xuan)

The gods bless and protect the people. The inconspicuous Dalin Wusheng Temple is hidden in a secluded alleyway. Although the temple does not boast a majestic grandeur, the resident Holy Emperor Guan has blessed the people of Dalin and overseen countless miracles in the form of divination block tossing. Many have borne witness to its divinity. Our concept is based on the practice of divination block tossing, which symbolizes the blessing of the gods: yellow symbolizes the god's divine brilliance, the green poncho, cloud patterns, and the blue and white paper quilling designs each represent the land, sea, and sky and personify the unity between humans and the heavens. Streams of light are generated on the Arduino platform via Bluetooth. With the blocks held in both hands, a sincere heart would light up the head-mounted block to show that the gods understand your inner thoughts and feelings (see Figure 11).

Figure 11. Images of team E's wearable creation themed "Jingle Bells" (source: this study).

4. Reflection and Discussion

4.1. Perspectives of the Students

To consolidate the students' reasons for participating in this innovative course, the top three performing design teams (twelve students: five from Team D, four from Team B, and three from Team E) participated in focus-group interviews after the course had concluded to share their personal opinions about the course. The interviews were held on the Monday of the 19th week at 10:00, 13:00, and 15:00. Each group's interview lasted 60–90 min. The entire interviews were recorded in audio, transcribed, and then coded. (Coding format: D1-Q1-03 refers to Student No. 1 from Team D, who was the third person to respond to the first question.) The five major perspectives of the students in general toward the course are summarized as follows.

1. Creativity stems from the interpretation and conversion of cultural symbols. Lynch (1960) suggested that various differences and relationships exist in the environment, and the observer employs a strong ability to adapt, choose, organize, and give meaning to what they see in accordance with their goals [16]. During the course, the students collected and interpreted cultural symbols around them based on their own observations and experiences. Their ability to do so was rooted in their prerequisite knowledge and literacy as well as their imagination of local stories from an observer's standpoint.

- Team D interpreted the symbols and metaphors of local cultural symbols by illustrating the atmosphere of a slow city and migrants returning home. They emphasized the application of paper materials, the dynamic aesthetics of wearing the creations, and the use of lighting to form images and cultural storylines (see Table 4).

Table 4. Team D members' ideas on the interpretation and conversion of cultural symbols.

Verbatim	Coding
Clothes and accessories are made of origami fish, which symbolizes migration. Many young people in Dalin leave their hometowns. There are many fish heads facing the protagonist in the work, hoping that young people can go back to their hometowns.	(D4-Q1-10)
The snail represents Dalin's guardian elf, who illuminates the road in the dark at any time and protects everyone.	(D5-Q1-15)
Three-dimensional window grilles are made of origami, and the cellophane is translucent and shiny, which means breaking through the tradition, and the feet are surrounded by trees and vines.	(D3-Q1-16)
The long skirt symbolizes the snail's saliva, and the traces of walking, and there are different kinds of fish, which means that the heart is attached to Dalin.	(D2-Q1-21)

- Team B was inspired by time traveling in which the interactions between antiques and childhood scenes resulted in conversations between childhood merriment and old spaces (see Table 5).

Table 5. Team B members' ideas on the interpretation and conversion of cultural symbols.

Verbatim	Coding
The abandoned shower room represents the childishness of the old space, with green iron grilles on the raincoat and apple green and purple floor tiles.	(B1-Q1-12)
There are many cats in the community, and they are talking with the enthusiastic and lively Jingle Fairy wearing a red scarf.	(B2-Q1-17)
Using slow-motion photography, the little elves walking through the alleys seem to be back in the Japanese alleys.	(B4-Q1-11)

- Team E was inspired by the spiritual sustenance of local religious beliefs. To symbolize the gods' spiritual blessing of Dalin residents, they fused innovative interactive technological elements with temple imagery, folklore, and colorful structures (see Table 6).

Table 6. Team E members' ideas on the interpretation and conversion of cultural symbols.

Verbatim	Coding
The temple is the patron saint and belief of the region, and the lights bring the image of hope and protection.	(E3-Q1-26)
The stand-up of moon blocks of Liyan in Wusheng Palace represents the coming of the gods. The color is bright red and green of traditional temple fairs.	(E1-Q1-02)
When the small moon blocks in the hand collide, the LED light of the big moon blocks on the head will be triggered and light up, representing the feeling of the coming of the gods. Use exaggeration to collide with traditional elements.	(E2-Q1-25)

2. The learning outside-the-classroom approach reinvigorated the students' curiosity and motivation. Huang (2013) suggested that the prerequisite for shaping new cultures is for people to leave their personal space, show concern for society and their surroundings, and reassess themselves based on their position in the world [25]. In the post-lesson interviews, several students divulged that they grew up in rural areas or that their grandparents had lived in rural areas. Taiwan's economic boom, however, has changed livelihoods as people have moved to the city, thereby widening the urban-rural gap. When they had the chance to revisit rural areas and observe agricultural landscapes, the students had fond recollections of their childhood, which triggered ripples of nostalgic affection and imagination (see Table 7).

Table 7. Student perceptions of learning outside-the-classroom.

Verbatim	Coding
Impressed to go out and enjoy the course schedule.	(E1-Q4-01)
Few teachers take us out of school to attend classes. After seeing the experience with my own eyes, I will have more ideas before making work.	(D5-Q2-03)
Create after actually feeling, the things you make will have feelings.	(D4-Q4-05)
You can go out to play for the first time in class. I was shocked to see things that I couldn't see before, like the stories of old theaters. The tour guide told a lot of secrets about Dalin and interesting stories about residents' lives. Our younger generation doesn't know the real face of Taiwan.	(B1-Q3-03)
Most of the students are very willing to spend time on this course. Although it is troublesome to go to Dalin all the time, I am very happy every time I go to Dalin to find inspiration.	(B4 -Q3-13)
I feel that I usually see too few things. If I didn't go to that community to see so many things, I wouldn't have seen a lot of connotations.	(E2-Q6-02)
Going outside is not just in the classroom, digging out local characteristics.	(B2-Q6-02)

3. Gaining a sense of achievement and confidence through learning-by-doing. By answering questions during the learning by doing the teaching approach, the students were able to systematically activate their insight and observation skills to identify target users and solutions through group discussions. This process of searching data to solve problems is in line with the principles of Dewey's learning-by-doing approach and is the primary goal of DBL, i.e., the most effective learning outcomes are acquired through problem-solving (see Table 8).

Table 8. Student perceptions of learning-by-doing (1).

Verbatim	Coding
I like to choose the objects I want to make, and I am very excited when I see shelves full of materials.	(E2-Q4-21)
Origami for the first time requires patience, and it often breaks accidentally, but it is amazing, to see a piece of paper turn out to be very powerful. In the future, I would like to continue to study.	(B1-Q3-09)
I like that after the work is finished from the sketch, the whole work is then shot in real life. The work is very beautiful and has a sense of accomplishment.	(D2-Q4-06)
The overall sense of accomplishment the moment the work is completed.	(B2-Q3-10)

In a TED talk, sports psychologist Dr. Ivan Joseph stated that creative confidence is like muscle strength: it can be improved through training and gaining experience [26]. In general, people with more creative confidence are more capable of making good decisions, are willing to try new things, and find solutions to overcome adversities (Table 9).

Table 9. Student perceptions of learning-by-doing (2).

Verbatim	Coding
During the process, I was a little anxious, had too little time, unable to complete it, and there were many negative emotions. But in the end, the team completed the finished product together and won awards in the competition. The feeling of being recognized after suffering first, I feel a sense of accomplishment.	(E1-Q7-02)
It feels very fulfilling to finish the cloak, and I like that everyone stays up all night doing it together.	(E3-Q4-06)
Although I feel tired during the creation period, it is very fulfilling and special. I am very excited that the work can return to its original place and interact with the space.	(D3-Q2-05)
At the presentation of the results, everyone's works are very interesting, and everyone is on the stage together.	(B2-Q3-02)
In the beginning, you need to overcome the eyes of others, but some persistence is necessary, so do it if you feel confident.	(D1-Q3-08)

Axel Honneth stated that when a person receives gratitude from society, they recognize their value and worth to society and others. This recognition allows the person to discover their usefulness to society and others [27] (see Table 10).

Table 10. Student perceptions of learning-by-doing (3).

Verbatim	Coding
I like the feeling of returning to Dalin after the actual operation. It is a good thing to give back to it with my own strength and help it with my thoughts on this town.	(D1-Q4-04)
Dalin has a common memory of us coming from the countryside.	(D5-Q2-07)
Help towns develop (discover) local characteristics that cannot be replaced by others, and will want to join the community to assist in the future.	(D1-Q6-03)

4. Creating more possibilities through the joys and sorrows of teamwork. Shan and Ho (2003) indicated that teamwork is characterized by helpfulness, coordinated efforts, a shared approach to working, open communication, and friendliness [28]. For art students, however, teamwork is often a major obstacle because students prefer and are used to making creations by themselves, in freedom and without constraints from others. Even though they have excellent individual performances, they crumble during teamwork efforts and are unable to listen to others or express themselves to others, and they have poor emotional quotient levels. By implementing design-based learning and teamwork tasks, this course exposes students to longer opportunities for balancing their relationships with others. This is important in teamwork as some people are natural leaders while some prefer to be subordinated (see Table 11).

Table 11. Student perceptions of teamwork (1).

Verbatim	Coding
This course pays attention to teamwork, and it is really difficult for one person. I used to think that doing things alone is more efficient, but this time I have a chance to think that the group is not bad.	(D4-Q3-06)
If you have any ideas, you must speak them out. Some team members may be afraid of being denied or afraid to speak up. Our group was very excited during the discussion as if they were debating, but it was fine after the discussion.	(D3-Q7-2)
In my department, we all created by ourselves. This time we all made it together. No one was particularly tired or idle. We all thought made and cut together . . . It was hard work but fun.	(B1-Q7-05)

Cooperation requires expressing opinions, sharing tasks, taking coherent action, and excellent communication. Rapport is formed between team members when, after prolonged acquaintance, they get along well with one another. Interestingly, even when each team member had their own firm beliefs (their pursuit of perfection), they were still able to work as a team to produce creations that were consistent with their designs and that surpassed their expectations. The students gained more experience in experimenting with different materials and methods, and overcame their shyness when performing in the community with their teammates. In addition to gaining more interactive experience, they also formed friendships with kindred spirits. Even when everyone insisted on pursuing their own way to perfection, the students nonetheless worked well as a team (see Table 12).

Table 12. Student perceptions of teamwork (2).

Verbatim	Coding
I insisted on a lot of things. I thought the window grille was ugly after it was finished. I took it down and tried three different materials before it succeeded.	(D3-Q4-11)
I stick to film quality.	(D1-Q4-12)
The persistence of the team makes our work perfect, thank you for everyone's persistence, and let us keep doing it.	(D4-Q4-27)
There are so many situations in the process that make people want to give up, but in the end, it is persistence, so I want to cherish it very much.	(B4-Q6-07)
I would like to thank my team members for their hard work in making the quality of the work achieve excellent results, and I would also like to thank the teachers for their hard work so that our creative ideas can be revealed and put into practice.	(B3-Q3-05)
Learned a lot from the team members and enjoyed the cooperation.	(E3-Q5-02)
During the process, we were arguing about the design performance. (Ha) In the end, the quarrel became very pleasant.	(E2-Q5-03)
The risk of cooperation is shared by everyone, which is more efficient, and it is great to have a chat partner.	(E1-Q4-26)

5. Discovering one's unique interests and expertise through diverse exploratory tasks during the course. Wu (2019) found that regardless of their academic achievements or social participation, university students were capable of gaining a sense of accomplishment and reinforcing their confidence when they expressed themselves [2]. The curriculum of the course in this study was designed in accordance with DBL. The students would seek solutions through discussions or learn new things from external sources when they encountered problems. This indicates that every student had their own talent and had opportunities to discover their strengths and interests when they were dealt with different possibilities for exploration and stimulation. These experiences gradually became their nourishment and source of empowerment as they intangibly unlocked their hidden potential (see Table 13).

Table 13. Student perceptions of diverse exploratory tasks.

Verbatim	Coding
The most impressive thing is origami. The first time I came into contact with it (laughs), I was crazy about folding, and then I started to pay attention to origami skills.	(D3-Q3-01)
Because origami is difficult to fold, I thought it was cool when I first came across it.	(E2-Q3-05)
I insisted on various camera angles, and later went to take photography courses and paid attention to the application of clothing styling.	(D2-Q3-02)
I take photography classes, learning photography skills, dynamic photography, and various composition.	(D1-Q3-03)
Interactive art has always been difficult, but after getting in touch with it, it is really interesting and I really want to learn it.	(D5-Q3-05)
The creative thinking unit is very interesting, the teacher's course presentation file is very exciting, the expression of crack transformation is great, and the use of paper to make clothes is also amazing.	(B1-Q3-14)
The bionic design is so cool, I never thought that nature can be our teacher everywhere, and the example of machinery using wind and kinetic energy to rotate itself is attractive.	(E1-Q3-15)

4.2. Reflection of the Teacher

After a semester of the 18-week course, the presentation of students' creative works, the feedback on students' core competencies self-evaluation, and the perspectives of three groups of students' focus group interviews were assessed. The teacher reflected on the course and summarized the feasibility of designing and implementing innovative courses

under three themes: conversing with methods, conversing with cultures, and conversing with teams.

1. Conversing with methods. This study applied the learner-centered learning teaching strategy in combination with DBL so that students could learn outside the classroom and connect with their surroundings, thus generating more motivation and direction. Learning by doing allowed them to have practical hands-on experiences in which they experimented with various materials and new technologies and widened the depth and breadth of their perspectives, thus sparking more creativity. Lastly, by implementing multidimensional evaluations, the teachers were able to identify the advantages and drawbacks of the curriculum design and the students' learning habits and genuine opinions, which served as a reference for future revisions to the teaching approach. Rapid social developments in recent years have broadened the scalability of design thinking and creating. Therefore, this teaching method should be more in line with the market situation and environmental conditions, with revisions and adjustments made whenever necessary. This is especially important in teaching art design courses, as teachers not only have to impart theoretical knowledge, but must also be able to design practical tasks to increase the significance of accumulating knowledge and experience. When correct teaching methods are used, students will react positively to teachers' dedication and useful teaching content.
2. Conversing with cultures. The course connected local agricultural and rural resources to simulate the students' thinking skills with respect to humanities exploration, media integration, innovative performance, and localized implementation. This concept is not merely a sudden flash of inspiration, but an entire storyline about a life or some other issue. An environmental image is the result of the mutual effects between an observer and their surroundings. Through different perspectives, students learned about the diversity of people, matters, time, land, and objects in urban landscapes, thus expanding the meaning of observing. The students also exuded different levels of self-confidence through their creations.
3. Conversing with teams. The course emphasizes teamwork and interdisciplinary co-teaching, as well as the 4D framework (discovering, defining, developing, delivering), to enable the students to improve their practical skills and rapidly transform their ideas into action while continuously making revisions and adjustments to complete their creations. The process of teamwork is marked with highs and lows and it takes time for team members to get along well with each other. However, with the correct materials and a spirit of experimenting with different approaches, the students overcame their reservations about performing in public, took their share of the blame for making mistakes, and enjoyed the process of chatting and debating. They truly experienced the value of having a friend in need. The students were also grateful for the opportunity to cooperate with one another as they found that, instead of doing it alone, they required a partner to make their creations. Additionally, interdisciplinary co-teaching allowed the experts to impart knowledge about diverse technical concepts to the students and break down the barriers or difficulties of teachers teaching alone, thus adding more creativity and modernity to the overall course.

Design-based learning (DBL) with the Double Diamond (4D) design process combined design thinking and design practice education methods. It conducted a series of experiences, capture, transformation, deconstruction, re-organization, interpretation, and practice through the process of learning by doing [10]. Students can not only learn the ability to solve problems but also improve their ability to communicate, share, and team-work in group learning. It indicated that the introduction of curriculum design thinking in the new era increased students' new learning perspectives and further understanding of what is meant by the foundation of innovation, the breakthrough of creativity, and the value of creation.

5. Conclusions and Suggestions

Tertiary education should not only stress enhancing students' professional knowledge but also underscore their thinking skills and problem-solving capabilities. After experimenting with various teaching methods, the researcher concludes that design should not only be confined to objects, but more importantly, the underlying human-to-human, and human-to-environment relationships. As such, design creations can be applied in life more actively to create greater value. The curriculum enabled students to gather local elements by starting from the standpoint of agricultural spaces and cultural contexts. By mixing paper-folding techniques with other composite materials as well as interactive Arduino lighting modules, the students produced wearable creations that reflected their imagination of the current cultural landscapes. Lastly, through photographic compositions and aesthetics, the team members wore their customized creations and took part in photoshoots around the community to evoke their imagination of specific cultural spaces and cultural stories. The students perceived this series of curriculum designs as a novel, out of the box, challenging, and interesting activity, and as a suitable platform for younger generations to express their opinions on current issues. According to this purpose, the key research results were as follows:

First, the quantitative results showed that the students experienced positive growth in their core competencies of "team communication", "implementation", "field-based knowledge and skills", "technological value", and "reflection". The Wilcoxon signed ranked test results reveal that after taking the course, the students significantly improved their "field-based knowledge" and "skills and technological value". This suggests that the integration of theory and practice evoked the students' curiosity and motivation, and the combination of learning and living environments expanded their views and allowed them to acquire more enjoyment and knowledge. The introduction of new technology broadened the scope of their imagination.

Second, the five major perspectives of the students in general toward the course are summarized as follows. (1) Creativity stems from the interpretation and conversion of cultural symbols. (2) The learning-outside-the-classroom approach reinvigorated the students' curiosity and motivation. (3) A sense of achievement and confidence is gained through learning by doing. (4) More possibilities are created through the joys and sorrows of teamwork. (5) One's unique interests and expertise are discovered through diverse exploratory tasks during the course. During the process of innovative thinking and hands-on experience, the students became more confident, gained practical skills, and naturally came to relish the sense of achievement brought on by their efforts. They also found opportunities to infuse vitality and imagination into community spaces.

Finally, the teacher reflected on the course. (1) Conversing with methods: design-based learning (DBL) with the Double Diamond (4D) design process, to bring students more creativity and motivation. (2) Conversing with cultures: step out of the classroom to activate the students' five senses to explore and create inspiration. The diversity of people, things, time, place, and cultural landscapes had become the best nutrient for students to learn, and it also increased their sense of identity and self-confidence. (3) Conversing with teams: the student team achieved design practice in the division of labor, joint learning, exploration, and communication, and also under the collision of introducing cross-field teaching, it stimulated more sparks of innovation for students.

It is worthy of congratulations that the students' work "Hi Dalin! A conversation with slow-paced life" won a special award in the "Innovation, Creativity, and Entrepreneurship" three-creation competition of the Smart Life Integrated Talent Cultivation Program of the Ministry of Education in Taiwan. It was the greatest affirmation of the efforts of the course students. Moreover, the school courses entered the community, and after a long period of communication, a relationship of mutual trust and assistance was established. We were also invited to be partners of the "Community Empowerment Project". Thus, curriculum planning that combines design-based learning (DBL) with the Double Diamond (4D) design process has positive feedback on teaching innovative design. It can nurture

students' active stance, proactivity, creativity, social compassion, and interdisciplinary and integrated thinking skills.

In addition, due to the time factor and the purpose of this research, this study only conducted focus interviews of the top three teams with the best overall performance. In the future, curriculum planning for all students to be interviewed can provide a more comprehensive understanding of students' views on innovative teaching methods. Additionally, the gap between different groups of students can be analyzed, and more complete insights on instructional design-based learning (DBL) and the 4D design process can be put forward.

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Appendix A

The questionnaire of the student five core competencies scale.

Dear students: This questionnaire mainly wants to know the status and thoughts of each student's five core abilities before and after the course of "Introduction to Design" this semester, so please tick the box with your exact thoughts at this stage.

No	Question	strongly disagree	disagree	neutral	agree	strongly agree
core competence: team communication						
1	I can listen to the professional opinions put forward by team members.	1	2	3	4	5
2	I can give back my ideas to my team members.	1	2	3	4	5
3	I can understand the main direction of the discussion when discussing it with team members.	1	2	3	4	5
4	I can understand the professional terms used by team members when communicating.	1	2	3	4	5
5	I can use effective communication tools to facilitate communication with team members.	1	2	3	4	5

No	Question	strongly disagree	disagree	neutral	agree	strongly agree
6	I can work together with team members to complete the task objectives.	1	2	3	4	5
7	I enjoy working with team members to accomplish mission goals.	1	2	3	4	5
core competence: implementation						
8	I can actively discover problems encountered in the process of teamwork tasks.	1	2	3	4	5
9	I can propose practical solutions to problems identified during teamwork tasks.	1	2	3	4	5
10	I can evaluate how I was doing in teamwork when working with team members on tasks.	1	2	3	4	5
11	I can evaluate how my peers were doing in teamwork when working with team members on tasks.	1	2	3	4	5
12	I can evaluate how the overall performance of were doing in teamwork when working with team members on tasks.	1	2	3	4	5
13	I can make specific suggestions for improving the performance of the teamwork after completing tasks in cooperation with team members.	1	2	3	4	5
core competence: field-based knowledge and skills						
14	I can notice current conditions and trends in rural communities	1	2	3	4	5
15	I can understand the advantages, disadvantages, and characteristics of spaces in rural communities	1	2	3	4	5
16	I can understand the distinctive places or cultural stories of the spaces in rural communities	1	2	3	4	5
17	I can understand the domain knowledge of the field (e.g., size, style, media, sense of space) when performing spatial creation in a rural community.	1	2	3	4	5
18	I can understand the correlation between the domain knowledge of the field (e.g., customs, human geography) when performing spatial creation in rural communities.	1	2	3	4	5
19	I can propose solutions to problems when performing spatial creations in rural communities.	1	2	3	4	5
20	I have grown in domain knowledge while performing spatial creations in rural communities.	1	2	3	4	5
core competence: technological value						
21	I can notice the current trend of interactive technology	1	2	3	4	5
22	I can understand the basics of interactive technology.	1	2	3	4	5

No	Question	strongly disagree	disagree	neutral	agree	strongly agree
23	I want to combine my work with interactive technology	1	2	3	4	5
24	I can propose a form of expression that combines space creation with interactive technology	1	2	3	4	5
core competence: reflection						
25	I can understand my preferred learning style (e.g., prefer reading or learning by doing).	1	2	3	4	5
26	I can understand my preferred creative methods (e.g., individual creation, team creation, single material creation, and mixed media creation.	1	2	3	4	5
27	I can understand the ways in which I am good at interacting with the outside world (e.g., oral, written, non-verbal, drawing, and digital media).	1	2	3	4	5
28	I can understand my role in teamwork (e.g., note-taker, leader, reporter, innovator, executor, chore, etc.) when working with team members on tasks.	1	2	3	4	5
29	I can understand why everyone with different specialties has different perspectives when working with team members on tasks.	1	2	3	4	5
30	I can reflect on myself from the interaction with teamwork when working with team members on tasks.	1	2	3	4	5
31	I can generate new ideas from the interaction with teamwork when working with team members on tasks.	1	2	3	4	5
32	I can clearly understand the problems encountered in the completion of the current work task when working with team members on tasks.	1	2	3	4	5
33	I can actively seek solutions to possible problems encountered when working with team members on tasks.	1	2	3	4	5
34	I can understand the learning objectives of this course	1	2	3	4	5
35	I can fit into the learning method of the course	1	2	3	4	5
other opinions:						

Appendix B

The questionnaire of the course feedback survey.

No	Question	strongly disagree	disagree	neutral	agree	strongly agree
1	The teacher is fully prepared before class and teaches according to the syllabus.	1	2	3	4	5
2	The teacher curriculum design can enhance relevant practical experience.	1	2	3	4	5
3	The teacher's explanations are clear and organized, making it easy for students to understand.	1	2	3	4	5
4	The teacher can demonstrate relevant practical skills in a timely manner.	1	2	3	4	5
5	According to the situation of the students, the teacher can provide practical operation opportunities and individualized guidance.	1	2	3	4	5
6	The teacher values student learning responses and responds appropriately to questions.	1	2	3	4	5
7	Teacher–student interaction is good.	1	2	3	4	5
8	The teacher assesses student learning outcomes (e.g., assignments, tests, reports, portfolio presentations, learning attitude, etc.), which can objectively reflect students' learning performance.	1	2	3	4	5
9	The teacher is serious and enthusiastic about teaching.	1	2	3	4	5
10	My absence status in this course:	(1) more than 7 times	(2) 5–6 times	(3) 3–4 times	(4) less than 2 times	(5) never absence
11	My attendance status in this course:	(1) less than 1 week	(2) 12–13 weeks	(3) 14–15 weeks	(4) more than 16 weeks	(5) all attendance
12	My attitude towards this course:	(1) strongly not serious	(2) not serious	(3) neutral	(4) serious	(5) strongly serious
13	The teacher of this course respects gender equality and do not use sexist language or sexually treat students with different attitudes.	1	2	3	4	5
other opinions:						

Appendix C

The interview outline of the focus group.

1. Please talk about the work created by your teamwork (form, technique, characteristic, connotation, symbol, concept . . .).
2. Have you ever encountered the same learning method before?
3. Which part has impressed you the most with the course? (or which time, which type)
4. What is your favorite part of the course?
5. What was the most difficult part of the course?

6. What have you learned in this course? What changed? (change in thinking/practice)
7. In your opinion, to complete a creative design of a wearable device with the theme of rural space, what do you think is lacking in the teaching of the course (or can be further improved)? What is lacking in teamwork learning (or can be further improved)? What is lacking in personal learning (or what can be further strengthened and improved)?

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Article

From Digital Collection to Open Access: A Preliminary Study on the Use of Digital Models of Local Culture

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Abstract: In the past, most cultural content was in a passive state of protection. In recent years, with the popularity of digital printing and the emergence of the concept of open-source sharing, it provides a new idea for cultural preservation. Using cultural elements from the Taitung region as a sample, this study established an open-source database, and completed the production of 60 digital models and the archiving of related materials. Based on the concept of open-source sharing, our research hopes that this database can be applied in more places. Through surveys, it could be concluded that, when the models are designed in parts and are easy to print and display, it is more conductive for the models to be used in promotions and applications. It is expected that each township will have its own localized 3D model database. Through the open-source localized digital model's unrestricted and free features, under the influence of COVID-19, it can also allow people from all over the world who cannot visit these places in person to print the local cultural content remotely, so as to have a three-dimensional under-standing of Taiwanese cultural objects. It is expected that the localized 3D model databases will help promote local cultural improvement and move towards local innovation.

Keywords: open-source; local culture; digital models; 3D printing

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1. Introduction

In response to the rise of digital tools and open-source sharing and co-creation, digital manufacturing and open-source sharing have become new trends in the industry in recent years. Cultural content and objects should keep pace with the times and become closer to people's lives. Nowadays, digital manufacturing tools have become digitalized, affordable and popular. Open-source databases of 3D models for free downloading and printing are flourishing, and it is increasingly common for users to download what they print. The world's first 3D model open-source database, Thingiverse, emerged in 2008. In Taiwan, the first 3D model search platform, Yobi3D, was established by a non-governmental organization in 2014, and in the following year, the Industrial Development Bureau of the Ministry of Economic Affairs also established an official 3D model platform, Fast Lab. To date, there are dozens of common 3D model open-source platforms domestically and internationally. However, the content of the platforms is only about dolls, mechanical parts, and household items. The applications of 3D printing worldwide are primarily on consumer products (29%), automobiles (19%), medical care (13%), education (10%), space (8%), and industrial machinery (7%). Moreover, 3D printing technology has been used in various fields, such as society, technology, education, and medicine, with varied performances. Tseng and Wang (2019) applied 3D printing to prosthetic limbs through teamwork and open-source design, making the process faster and more relevant to users [1]. With the emergence of 3D printers that can print circuit boards or food, the content subject to 3D printing has been much more than ever before, but the cultural content is rarely a digital print target.

In the past, cultural contents have been passively preserved in the form of the original artifacts, texts, images, audio and videos, and guiding websites, with the goal of long-term collection and appropriate preservation. In view of the maturity of 3D modeling technology, this study proposed the concept of open-source local culture, in which local cultural contents are assembled into a digital database platform in the form of 3D modeling. The platform introduces the spirit of open-source sharing and popularized 3D printing technology, which will enable more people to actively download local cultural contents remotely and print them for value-added applications. With the technological changes of the times, cultural relics have been preserved in various ways and the purposes of presentation vary at different times. From 2002 to 2007, the National Science and Technology Council conducted a digital collection to select culturally valuable objects, with the main purpose of preserving cultural objects in the form of photos, videos, and illustrations. Since 2008, the Ministry of Culture has been promoting the cultural creative industry by adding creative value to cultural contents through various translations in 13 other categories, such as commodity packaging, cultural and creative goods, film and television, music, and animation and comics. In response to the changing times and industrial model, the government and industry have encouraged the connection of key texts such as words, images, and stories, and the diverse licensing of intellectual property (IP) has become the key to unlocking cross-disciplinary products. Liao and Chen [2] pointed out that the integration of digital content, user services, and technological tools through technology in the local culture is conducive to the intersection of culture and technology. For example, in the publishing industry, through IP licensing, creative texts are extended to film and television, games, comics, music, and performances. In light of digital tools and the concept of open-source sharing, cultural contents should keep up with the times and be more relevant to people's lives. Under the trend of globalization, "localization" is exactly a valuable asset for Taiwan to express its identity to the world. The booming digital technology and open-source networks are good ways for the world to see Taiwan's local culture [3]. The creation of open innovation platforms by governments or citizens, as a powerful bridge to user innovation, can also be seen as a social movement [4].

The purpose of this study is to build an open-source database of cultural content in Taitung, which is a disadvantaged area in terms of scientific and technological resources, and to explore the print application and impact of the open source of local cultural content as a reference for the subsequent open-source process of local cultural contents. Taitung is rich in natural products and cultural diversity; however, due to its remote geographical location, digital resources are comparatively scarce out there. From the view of fulfilling the social responsibility of universities, universities should have gratitude for the source of benefit. It is expected that more people can get close to Taitung's local culture through digital innovation, thus highlighting the potential of digital design in remote areas to transform knowledge circulation under the trend of open-source sharing.

2. Literature Review

2.1. Content and Connotation of Local Culture

Culture is the soul of a nation, and any culture with historical, artistic, and scientific values for cultural preservation is a precious national asset. From the perspective of locality, local culture is essentially a reflection of people's local life and culture. It is by making good use of local cultural assets, such as geographic resources, human history, and folklore activities that the unique charm of a place can be built. As globalization is progressing all around us, the exchanges between different cultures are becoming more frequent, and cultural globalization seems to have served as a driver of "cultural convergence". In fact, while globalization is progressing, the trend of respecting multiculturalism and emphasizing local culture has never diminished. Lee [5] argued that culture is the product of common human activities, which includes not only the tools and objects that people use, the rules and regulations that sustain social life, and the artistic products of spiritual life, but activities of the human mind in the process of creation [6,7]. Each place has its

own local symbol, and a "local place" is a local, regional, and localized object, location, field, or area which sets itself apart from anywhere else in the world by its local features, such as atmosphere, characteristics, and style. The content of cultural assets can be divided into tangible and intangible (material and non-material), which are the result of cultural accumulation in the past and leave historical traces in the places where people live today, some of which are tangible structures or objects, while others are non-material skills and arts [8].

In the Cultural Heritage Preservation Act, states: "The term "cultural heritage" referred to in this Act means the following designated or registered tangible or intangible cultural heritages which are of cultural value from the point of view of history, art or science. Tangible cultural assets include nine categories of monuments, historic buildings, monumental buildings, groups of buildings, archaeological sites, historic sites, cultural landscapes, antiquities, natural landscapes, and natural monuments; and intangible cultural assets include five categories of traditional performing arts, traditional craftsmanship, oral traditions and expressions, folklore, and traditional knowledge and practices".

At the local level, it is indeed necessary to have a cultural core to lead the development of local characteristics. Regarding the classification of local cultural assets, many scholars have followed Professor Kiyoshi Miyazaki's five categories of "people, culture, place, production, and landscape" to classify local cultural resources [9,10]. The core content of these five points is as follows: (1) People refers to the satisfaction of the common needs of local residents, the management of interpersonal relationships, and the creation of well-being in life. (2) Culture refers to the continuation of local history and culture, the management of artistic and cultural activities, and lifelong learning. (3) Place refers to the maintenance and development of the geographical characteristics of a place, and the emphasis on local characteristics. (4) Production refers to the development and marketing of local products, and the collective promotion of local economic activities. (5) Landscape refers to the creation of unique local landscapes, the sustainable management of the living environment, and the self-involvement of the residents in the development of the local area.

In Taiwan, the classification of local culture includes local tourism, craftsmanship, maintenance of cultural assets, and preservation of groups of monuments, such as the creation and publication of fine arts, and the establishment of culture and arts, living arts, agriculture, and fishery [11]. Local culture is essentially a manifestation of local life and culture to build up the unique charm of the place based on local thinking, using local resources, talents, and conditions, which is an endogenous and autonomous re-creation in the area [12]. Local culture is marked by the characteristics of local culture, whether from the five categories of people, culture, place, production, and landscape, the four categories of life, production, ecology, and living creatures, or the three categories of culture & history, technology, and nature, all of which are the contents of cultural industry [8]. In terms of practical cultural design, cultural content can be divided into three levels: physical or material, social or behavioral, and folk or religious [13]. In addition to the academic perspective, in the practical design of the industry, Cheng [14], with years of experience in the design of local culture and creativity, summarized the content of local culture in his book into local culture and history, ecology, nature, legend, and craft. This study synthesizes the above academic theories and practical views and proposes the orientation and details of a local cultural content survey, as shown in Table 1.

2.2. Open-Source Sharing Age

The term "open source" emerged in 1998. In a modern society where knowledge is exploding and resource sharing is a necessity, an open-source attitude means transparent sharing and cooperation with the public. The term "open source" originally referred to a mechanism that opens up its design for free modification by all users and was mostly used in the software development process, nut nowadays this mechanism has gradually evolved into a concept and even an attitude in life. It means the way of accelerating the development of products, projects, and programs by opening them up to public participation, discussion,

and modification, thus increasing transparency and public welfare [15]. Hacker culture and the free software movement are two examples of open source; they are seen as part of the progress even when they failed [16].

Table 1. Orientation of local cultural content survey.

Literary and Historical Survey	Ecological Survey	Landscape Survey	Craft Survey	Folklore Survey
Historic buildings	Agricultural specialties	Mountain	Traditional craftsmanship	Religious stories
Temples	Native/Specialty plants	Rivers/Seas	Totems/Signs	Festivals
Featured buildings	Native/Featured animals	Flatland	Technical talent	Folklore stories
Cultural landscape		Tourist attractions		Legendary stories

Source: this study.

Open-source sharing offers a fourth mode of exchange in the world which is not under the premise of profit. The current world of information has entered an era where scarcity, distribution, and hierarchical modes of exchange are unsustainable. At this time, the open-source community provides a model that begins with "sharing to non-specific people" and proceeds through the process of "gathering contributions from all" to enable sustainable, successive, and shared creations to occur. In the public press release of the COSCUP'14 held at Academia Sinica in 2014, it was clearly pointed out that open source is not only about software but also about a spiritual attitude. Using the spirit of openness, COSCUP aims to make its technology available to others without royalties and to evolve into a model of collaborative development, which is widely used in computer science. The nature of open source can be likened to "a single spark can start a prairie fire". People can play and contribute their own power to contribute to society with a good idea and a good platform [17]. Because of its open nature and ability to quickly gather the power of the masses, the spirit of open source can often do, in a very short time, what one person cannot. Open source is often a distributed and decentralized approach to collaborative development, and the open licensing of research and creative output is a prime example of user innovation [4].

Today's information society owes its existence to the profound influence of the free and open-source culture. Furthermore, the current global eagerness in promoting 3D printing technology is also from the development of an open-source technology project called Reprap by Adrian Bowyer of University of Bath (UK). The research and development process is all based on an open-source file (open-source technology) of hardware and software, and all the relevant technical data are publicly available on the Internet. As a result, this product, which should have stayed in super labs or have been belonged to high-end technology for large-scale economic enterprises, has found its way into the life of the general public in just a few years and is increasingly popular among individuals and families. Nowadays, the applications of increasingly sophisticated online trading platforms are becoming more and more diversified. With the wide and far-reaching super-influence of the online community movement, when everyone can own a desktop digital manufacturing tool (e.g., 3D printers and laser cutters), industry and society are bound to embrace the new technology. EI Bedewy, Lavicza, Haas, and Lieban (2022) provided teachers and students with the open-source tool "GeoGebra" for learning the connection between math and architectural modeling, and the results of this study indicated that participants were able to solve the technical problems of model visualization more easily through open-source modeling resources and 3D printing processes, thus effectively enhancing the learning opportunities in STEAM education [18].

Taiwan has also been influenced by the spirit of open-source sharing, mainly by software workers in the early days. However, with the development of the licensing and self-creation culture of CC in Taiwan, people who work on texts, hardware, music, videos,

designs, education, and politics are now also participating in open culture [19], and the scope of resources is becoming more and more extensive. The Taiwan CC Project uses Mediagoblin as a benchmark for open-source licensing to release CC or materials in the public domain [20]. Open sources also include other text (such as Wikipedia), hardware (such as Arduino and Thingiverse), music (such as Blend and SoundCloud), video (such as YouTube and Flickr), design (such as Behance), education (such as Khan Academy and OCW), science (such as arXiv), and politics (such as g0v). Taiwan's first Digital Minister Audrey Tang is an open-source leader and one of the few people in Taiwan with international open-source community influence. In terms of cross-discipline, the popularity of input tools (touch, voice, gesture, and emotional signals) has brought more and more analog messages into the digital world, and the corresponding collaborative space has continued to decline its operational barriers and, along the new output methods (stereoscopic printing, augmented reality, and programmable matter), came into life. The content of open source is much more inclusive than a complex of print, audio, and text media.

In view of this, the issue of how to open up and provide multiple applications for the digitization of cultural contents has become an issue of concern. According to the Center for Digital Culture at Academia Sinica, Taiwan, the dissemination and circulation of knowledge in the digital age are based on the digitization of cultural content and the continuous evolution of information technology. In today's world where "knowledge has a price", how to enable the general public to appropriately use open and authorized data in a free network environment, and thus promote the co-creation and progress of local culture, has been the subject of continuous discussion and practice by various collection institutions. The former convener of the Center for Digital Culture, pointed out in the Open Museum [21] that "opening up" the right to use the collections, which includes the collection (determining the value of the artifact), interpretation (interpreting the meaning of the artifact) and creation (using the artifact to create), is open to all people and promotes the "democratization" and "digital affirmation" of cultural assets, thus facilitating the positive cycle of knowledge production through the multi-directional and multi-dimensional digital display. Cheng [22] proposed three features of the Open Museum. One feature is that the digital images of the collections are in the International Image Interoperability Framework (IIIF) format, which allows direct online viewing of large images regardless of the carrier. The second feature is that the collections have a higher chance of being found by search engines. The third feature is that the Open Museum's Online Exhibition Module service connects the collections with the exhibitions, allowing the public to click directly from the same page without any obstacles. From the above features, it is clear that the process and services of cultural content from collection to openness are all based on the idea of "easy access for the public".

2.3. Prototyping Technology and Self-Maker Spirit

Rapid Prototyping and 3D printing technologies have been developed since the 1980s. Today's 3D prototyping technology is different, but the main printing process is similar. First, 3D modeling is carried out by computer-aided design software, and then the finished design file is sliced by slicing software, and each slice contains the inner and outer contours of the product. Finally, these slice profiles are converted into G-code parameters to control the printing values of 3D printers [23,24]. Over the years, the process has continued to break new ground. The open-source community has played an important role in this wave of development because since 3D printing hardware and software have been made available to the community, talented engineers from all over the world have been able to collectively work to achieve the ideal of making 3D printing technology available to the general public. This community environment has led to a wide variety of new printer models, and the general public can easily evaluate the print quality, print speed, printable size, output stability, and price of various models, so that everyone can achieve the dream of "freedom to print and make any object" by choosing a 3D printer that meets their needs. With the help of open-source hardware and the Internet community, due to the advancement of

technology, the wave of self-makers has risen, and product manufacturing has moved from factories to homes and personal studios. The influence of digital software resources and smart machines on manufacturing has created a new wave of social and technological revolution [25], as digital manufacturing tools have become affordable and accessible, changing the way society works.

The digitization and personalization of manufacturing tools are not only for researchers or creators, but more importantly, they greatly affect individual self-makers and general public users. Each person can design according to his or her free creativity and functional needs and make the work that best meets his or her expectations [26]. Furthermore, through the Internet, it will be easier for each self-maker to open up his or her design information and manufacturing knowledge to the four corners of the world and share it, further breaking down social and cultural barriers. Lipson and Kurman [25] proposed that self-makers use digital manufacturing tools and various processing methods to connect, either directly or indirectly, digital data with various materials such as paper, wood, fabric, resin, and metal. While exploring the relationship between materials and processing methods through computers, and exploring the multiplication effect between the two, they also create data and objects. This is a different kind of production method from the traditional one, in which digital manufacturing tools connect abstract digital information with concrete materials. While they are the extremes of each other, a two-way communication is established between them. Moreover, 3D printers are inevitably becoming more affordable and personal, and the biggest source of profit from 3D printing in the future will not be the machines themselves or the consumables, but the image files and databases. With the development of 3D printing technology, the 3D printing industry has developed into a multi-billion-dollar market and continues to grow. Chang and Tsai [27] analyzed the features and community functions of several domestic and international digital modeling platform databases. In these databases, users are free to access high-quality, usable, and secure image files from model databases. Furthermore, enterprises and manufacturers can manage user-downloaded image files from databases and even have access to target users' biographical data.

Continuing the spirit of self-makers, with government subsidies and vigorous promotion and support from non-governmental organizations, Maker Spaces have blossomed in Taiwan. Since 2012, there have been many self-maker spaces in universities, colleges, senior high schools, vocational high schools, junior high schools, and elementary schools with excellent digital manufacturing tools, among which 3D printing equipment is the most common digital manufacturing tool. In principle, digital modeling combined with 3D printing is user-centered and both are considered as active and self-directed learning methods [28]. In school teaching, Bonorden (2022) used digital models of flowers in biology classes and 3D printed three-dimensional models to solve the problem of having only 2D pictures of plants and flowers in textbooks. The three-dimensional models clearly illustrated flower structures, thus improving the limited learning environment [29]. However, the prerequisite is that this can only be achieved if the teacher has modeling skills [30,31]. After a deeper understanding, this study finds that although there is no shortage of space or hard equipment, there is a lack of technical talents and digital creation content. Only a few professional teachers have modeling skills [32–34], and for most, it still takes a lot of energy and time to learn these new digital technologies [30,31]. The 3D open-source databases can solve this problem in a timely manner. Through CC authorization, they provide suitable digital 3D files for users to download and print freely to produce three-dimensional models and solve the dilemma of insufficient digital content and technology. Users can master what they learn. However, this can only be successfully practiced if the teacher has professional modeling skills, which is the prerequisite [30,31].

3. Research Method

Based on the concept of "cultural collection and re-creation" and to fulfill the social responsibility of universities, this study aims to investigate and inventory the local cul-

tural contents in Taitung. It selects the appropriate modeling themes and related objects through the principle of selection and records the size, material, and cultural and historical descriptions of the physical objects. The purpose of this project is to confirm the accuracy of the information on the objects created for knowledge dissemination and educational applications. The 3D dynamic model is constructed through staff training, and slicing software analysis and G-code are performed to make feasible the model printed. Finally, the 3D model files are uploaded to the open-source platform databases, the usability of the open-source platform is discussed, and the traffic data are analyzed to complete the open source of the local cultural contents in Taitung.

3.1. Inventory and Survey of Local Culture

There are three reasons why Taitung is selected as the target area. Firstly, Taitung is the third largest county in Taiwan by area, with a beautiful natural landscape, diverse human and cultural communities, and rich local cultural contents. Secondly, because of the far-reaching nature of Internet technology, Taitung, located in a remote rural area compared to other counties and cities, requires more aid to break the urban–rural boundary through the power of new digital technology. Finally, the researchers and their affiliated organization have the advantage of geographical location and connections in Taitung, which is conducive to this study.

Taitung County has one city, two towns, and 13 townships. Because of its late development, Taitung retains a rich aboriginal culture. According to the statistical report of the Taiwan Council of Indigenous Peoples Taitung's indigenous population accounts for more than 30% of Taitung's population, the highest in Taiwan. From the highest to the lowest indigenous population, the order is the Amis, Puyuma, Paiwan, Bunun, Rukai, and Atayal. In terms of tangible assets, aboriginal cultural relics and crafts of each ethnic group are quite diverse and rich. For example, the Puyuma are good at weaving rattan or bamboo utensils, using such techniques as square weaving, herringbone weaving, and hexagonal weaving to weave rattan baskets, rattan bags, and backpacks; the Paiwan have earthenware pots, glazed beads, bronze swords (three treasures of them), as well as cups and earthenware beads; their antiquities include human-animal-shaped jade penannulars and frog-shaped jade ornaments of the Hualgang Mount culture, whose totemic motifs all have deep cultural connotations of the aboriginal people. In terms of landscape and ecology, Taitung is bordered by the Pacific Ocean to the east, located in a tropical climate zone and facing the mountains near the sea, with a coastline of 176 km, the longest in Taiwan [24]. Taitung is also home to many animals, including wild boars, Reeves's muntjac, Rusa unicolors, and Pteromys volans in forests; Taitung also has many famous marine animals such as the dolphinfish brought by the tide, marlins in Chenggong Township, and Cypselurus in Pongso no Tao. In terms of architectural resources, Taitung has 47 featured buildings, such as Chinese Consolidated Benevolent Association, Taitung Thean Hou Temple, Baoting Art and Culture Center, Guanshan Station Kanzan, GoBen Farm, YiWan Taiwan Presbyterian Church, Lyudao Lighthouse, Lanyu Weather Station, and the chapel of St. Joseph Technical High School. In addition, the only Taitung architect in Taiwan e-Learning and Digital Archives Program of National Science and Technology Council—Mr. A-Yu Lu, whose architectural works, such as Taitung County Council, the Old Beinan Township Office, the Baosang Road Building, the Cave House (the old office building of Taitung County Tax Bureau), and San Hai Department Store, (shown in Figure 1) though an amateur, occupy an important place in Taitung's architectural history with his distinctive architectural style. In terms of intangible assets, Taitung's most well-known folklore belief of Bombing Lord Handan in the Lantern Festival enjoys equal popularity as Yanshui Beehive Fireworks Festival and Pingxi Lantern Festival for being the three major Lantern Festival folklore events in Taiwan. The indigenous people's festivals include the Paiwan Five Year Ceremony, Puyuma Mangayaw (Indigenous Hunting Festival), Tao Flying Fish Festival and Boat Launching Festival, and Bunun Ear Festival (Wikipedia: Taitung County Government, Taitung County

cultural assets, Taiwan's Indigenous Peoples Portal, and Taitung County of Indigenous People website). The relevant indigenous people's festivals are shown in Figure 2.

Figure 1. Diagram of Taitung's cultural assets. (Source: this study).

https://tour.taitung.gov.tw/content/images/static/3-6-12-0.jpg https://tour.taitung.gov.tw/zh-tw/attraction/details/1272 https://tour.taitung.gov.tw/zh-tw/news/details/5229

Figure 2. Indigenous people's festivals (Source: website of Taitung County Tourism Department).

Taitung is rich in land resources and diverse in humanities. However, due to its remote location, it is comparatively lacking in technological resources, so it is more appropriate to adopt a "proximate view" to select modeling objects and consider the difficulty of 3D printing objects. In the open-source network world, rural areas can also be the protagonists in the field of digital modeling, and a unique "digital culture experience in Taitung" can be constructed.

Through the above collected Taitung cultural contents, the following three principles of modeling priorities were established: (1) uniqueness and representativeness of local and cultural significance: according to the classification of local cultural industries by Liao [8] and Cheng [11], and visiting local cultural communities Taitung Sustainable Development Society and Taitung County Houshan Association of Cultural Work for their suggestions on local characteristics of Taitung; (2) the urgency of preservation: for instance, historical buildings are vulnerable to natural disasters, (3) popularity and celebrity: attracting the audience attention and leading to traffic for downloadable applications.

In this study, the Taitung culture digital model was developed by integrating five major themes, as shown in the table below, and the specific modeling objects are described below: (1) cultural artifacts: mainly Taitung's aboriginal artifacts and Puyuma ruins; (2) local ecology: Taitung's common forest animals and fish; (3) featured plants: mainly Taitung's representative agricultural products; (4) featured buildings: Architect A-Yu Lu is an important figure in Taitung's architectural history. He is the only Taitung native in the Ministry of Science and Technology's Digital Archives Program for Taiwan's architectural history, and the most popular tourist attraction of the Lyudao Lighthouse; and (5) cultural festivals: the people, places, and props involved in Taitung's unique religious festival of "the Bombing of Master Handan", as shown in Table 2:

Table 2. Modeling themes and related objects in Taitung.

Cultural Forms	Topics	Description	Related Modeling Objects
Tangible Assets	Cultural artifacts	Original folk crafts, totems, and decorations	Paiwan's bronze swords, glazed beads, earthenware pots, and cups.
	Local ecology	Terrestrial organisms, marine organisms	Wild boars, muntjac, Rusa unicolors, Cypselurus, marlins, and dolphinfish.

Table 2. *Cont.*

Cultural Forms	Topics	Description	Related Modeling Objects
	Featured Plants	Agricultural specialties	Sugar apple, Hibiscus sabdariffa, Navel oranges, a-bai, Areca catechu.
	Featured buildings	Featured buildings, historic sites	Taitung Country Council, the Old Beinan Township Office, Cave House, Kwong Hang Fat Building, and San Hai Department Store. (A-Yu Lu's buildings)
		Famous landmarks	Lyudao Lighthouse.
Intangible Assets	Folklore	Folklore, religious activities	The Bombing of Master Handan (Personnel: fleshly Master Handan, palanquin bearer, cannon thrower; Location, Props: Xuan Wu Tang temple, shrine seat, firecrackers, banyan leaf fan, broom.
	Festivals	Aboriginal festivals	The number of characters, clothing features, and props required for the Five-Year Ceremony.

Source: this study.

In addition to the above-mentioned modeling selection principles, this study also developed the principle of the print ratio, which was set at 1:100 for architectural printing, in response to the range of printing sizes of common 3D printers.

3.2. Cataloging Object Data

The metadata was set with reference to the digital collection databases and museums' collections and adjustments and revisions were made. The data catalog includes object names, 3D modeling drawings, and physical product print photos. There are four key points in the catalog: (1) Provide at least three keywords for each object, so that users can find it quickly, easily search cultural contents and related works, and increase an object's chance of being viewed; (2) Provide a "summary description" of an object, covering its actual size, the cultural connotation of the elements, and the design concept of the creator, to make it understandable for the public; (3) Provide digital model "3D printing parameters", such as Format, Printer, Rafts, Supports, Resolution, Infill for users' reference printing to reduce the chance of print failure and enhance the access value; (4) Adopt the six licensing terms of CC (creative commons), which have been promoted internationally in recent years. The object information cataloging format as shown in Table 3.

Table 3. Object information cataloging format.

Object Name	Object Code		
1. Basic Description	**2. Cultural and Historical Descriptions**	**3. Print Parameter Information**	**4. Pictures**
1.1. Keywords 1.2. Size 1.3. Material 1.4. Color	2.1. Cultural significance 2.2. Importance 2.3. Location	3.1.1. Extrusion layer thickness 3.1.2. Extrusion width 3.1.3. Shell (surface) thickness 3.1.4. Number of outer circles 3.2.1. Raft style 3.2.2. Support and object contact surface clearance setting value 3.2.3. Support angle values 3.2.4. Side skirt setting value	4.1. Original view of the object 4.2. Object digital modeling diagram 4.3. Screenshot of printing parameters 4.4. Object print completion diagram
5. CC License Terms			

Source: this study.

3.3. Building 3D Digital Models

The 3D models are built according to the modeling themes proposed above, and the modeling software is not limited to the creator's expertise and suitable attributes. Modeling

software in this study was mainly built with Maya, Z Brush, and Sketch up. Maya and Z Brush are suitable for building models of people, plants, animals, and artifacts, while Sketch up is suitable for building models of architecture. After the models were built, they were saved in .stl and .obj formats, which are two highly versatile 3D printing model file formats, and were used as the 3D digital model files for this study.

3.4. Confirm 3D Printing Parameters

From past 3D printing experiences, it can be learnt that not all 3D digital models can be printed smoothly, and this is the main reason why ordinary users have difficulties in 3D printing. For example, 3D models that are nearly 90 degrees or in the air may not always be able to be printed smoothly and must first be analyzed by slicing software to calculate the external support structure and help convert the 3D file into a slicing file, and then adjust the relevant parameters. This is to prevent the model from collapsing and failing when the user prints. Therefore, in this study, considering the ease of printing and convenience, each model was successfully printed and tested before uploading to the platform, and the values of the slicing parameters at the time of successful printing were also fully recorded to improve users' printing success rate, taking the Yin-Yang pottery pot as an example, as shown in Figure 3.

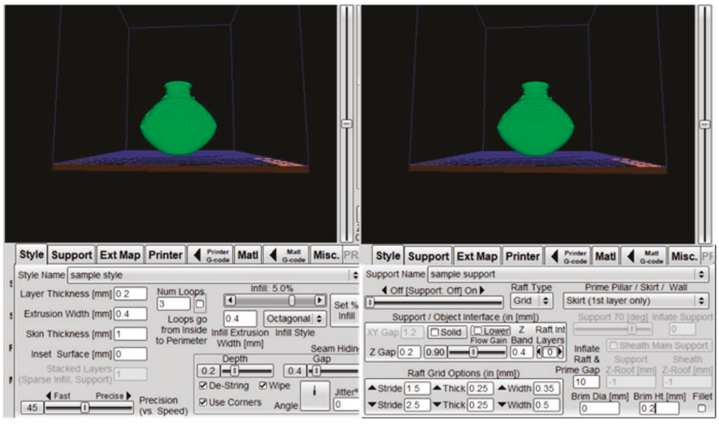

Figure 3. 3D printing of pottery pots with slicing parameter values. (Source: this study).

In 2020, this study published "Discussion on Common Problems and Solution Strategies in the 3D Printing Process", proposing 16 solutions to common problems in 3D printing. The 3D printing instruction focuses on basic parameter settings including the platform temperature, printhead temperature, printing speed, printing layer, outer wall thickness, density fill, base, and support material calculation. Before making a test print, it is important to check the scale of the model and make sure that the model does not violate the conditions and settings of the 3D printing device before printing.

3.5. Uploading Open-Source Platforms

A total of 60 digital models of Taitung culture were completed in this study, and the exhibits were presented on the platform as Figure 4. All of the works have been uploaded to the world's two most well-known and most-used open-source platforms, Myminifactory [https://www.myminifactory.com; (accessed on 20 January 2022)] and Thingiverse [https://www.thingiverse.com; (accessed on 20 January 2022)], and an account has been set in the Taitung Culture Content Zone for future file management, updating, and analysis.

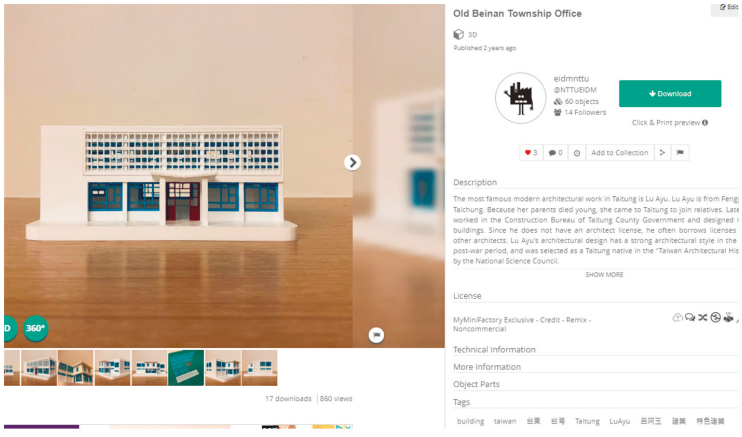

Figure 4. Open-source platform interface. (Source: this study).

The situation of works after uploading:

1. Since the first work was uploaded to Myminifactory (16 March 2019–10 September 2022), the total number of views reached 55,802, the number of downloads was about 1376, and the top 5 objects downloaded from this platform were: muntjac 47 times, Call of the Wild Orbiter 46 times, Deinagkistrodon 46 times, Lyudao Lighthouse 43 times, wild boars 42 times.
2. Since the first work was uploaded to the Thingiverse open-source platform (16 March 2019–10 September 2022), the total number of views reached 2581, the number of downloads was 9461, the top five objects downloaded from this platform in order were: Lyudao Lighthouse 417 times, Xuan Wu Tang in the Bombing of Master Handan 349 times, Kwong Hang Fat Information Co., Ltd., Hong Kong, China (an architectural work of A-Yu Lu) 309 times, Hibiscus sabdariffa 284 times, Cypselurus 383 times.

Each Taitung digital model uploaded to the open-source platforms includes four types: single-view digital modeling, 3D-view digital modeling, online 360-degree rotation operation, physical printing model, as shown in Figure 5; modeling and physical printing of personnel, places, and props required for the cultural festival of "the Bombing of Master Handan" were shown in Figure 6. This is to provide users with a variety of models for users to access, download, print, and use based on their needs, thus maximizing the diffusion benefit for advertising Taitung.

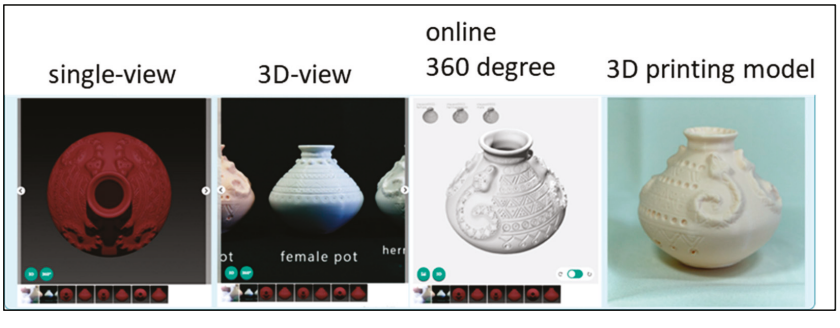

Figure 5. Manipulating the digital model and the printed physical model. (Source: this study).

Figure 6. The digital model and printed physical model of "the Bombing of Master Handan". (Source: this study).

4. Results and Discussion

This study took Taitung, a relatively disadvantaged area in digital resources, as an example, and proposed an operational model and a process for digitizing and open-sourcing local cultural contents for the reference of all cities and towns in Taiwan, with the expectation that all towns in Taiwan will have their own localized 3D model database. This study analyzes the application and suggestions of six junior and senior high school teachers with experience in 3D printer operation on the use of localized digital open-source models in the classroom, in the areas of indigenous culture, life technology, and visual arts.

4.1. The Digital Model You Would Most like to Try to Print and Reasons

Each respondent chooses the top three digital models. The six digital models the respondents were most interested in trying to print are Lyudao Lighthouse, animals (wild boars, Reeves's muntjac, Rusa unicolor), ceramic beads, ceramic pots, and Paiwan hunting daggers. They were chosen primarily because these models are well-known, have indigenous characteristics, and can be printed for display or collection. However, the respondents were not interested in 3D printing a model of plants and fish.

> I only know Lyudao Lighthouse, which is collectible and decorative (THT-C20220116).
>
> Taking into account the feasibility of printing in the design process, the Lyudao Lighthouse is suitable as an example for teaching "3D printed object design". The building itself is also unique and suitable for printing as a display or collection (THT-F20220119).
>
> Ceramic pots are very aboriginal (THB-A20220115).
>
> Ceramic pots can be used in classes to introduce the characteristics of the Paiwan, and the three models are very good examples (TMV-E20220119).
>
> The Paiwan hunting daggers are very aboriginal (THB-A20220115).
>
> It can be used as Paiwan specialties. Handmade hunting daggers are not easily available, so the printed ones can replace the real hunting daggers very conveniently (TMV-E20220119).
>
> Because of the small size of the ceramic beads, it is suitable for beginner students to learn how to operate the 3D printer and the subsequent process of removing the stand, grinding, and painting (TMT-D20220116).
>
> Even the details of a wild boar are there, which is very realistic! (THT-B20220116).
>
> These animals are so detailed and realistic that they are suitable for printing by light-curing as display materials or series collections (THT-F20220119).

4.2. Whether Digital Models Are Useful in Teaching or Life, and the Need for Using Digital Models

Among the five major types, the respondents thought that the "characteristic architecture" models were more helpful because the 3D models of buildings were designed in a block-like way, which made it easier for the viewers to understand the structure and characteristics of buildings, and the parts were easier to print and assemble successfully. Ceramic beads, which are in small sizes and various patterns, are also suitable for beginners

as a printing target, not only for successful printing but also for appreciating the aboriginal culture and art.

> In teaching practice, I have met many students who are interested in architecture, but currently, most of the buildings are presented in the form of flat drawings or models. It would help students differently if they could use 3D drawing and digital printing (THT-B20220116).
>
> Architectural models can be actually viewed in miniature, and even disassembled to make it easier for children to understand the structure and features of a building. A printed or 3D drawing is easier for children to understand than floor plans. The use of local architecture also better introduces children to local architecture (TMV-E20220119).
>
> From the perspective of teaching "3D modeling and printing technology" as the theme of the course, a model of a building with a "design of parts" would be a useful teaching example. In the teaching field, the author observed that when 3D modeling beginners were unable to grasp the design skills when designing 3D printed models, this would lead to failure in the 3D printing process. If I could use the work designed with the convenience of 3D printing under consideration as a solid example for the learners to observe and imitate, it could help them to improve their design skills in 3D modeling, which in turn would improve the success rate of their work when printing (THT-F20220119).
>
> It will help teachers of humanities courses who are not familiar with modeling to approach digital technology and allow students to appreciate aboriginal culture and art and understand the elements of creation (THB-A20220115).
>
> The high time cost of 3D printing and no-frills machines in schools led to a higher failure rate. However, in order to allow students to have more contact with each printing step, we must choose simple and easy-to-succeed 3D modeling. Hence, ceramic beads in small sizes were selected as they could be painted and strung into a piece of jewelry. The initial application of the course is to teach students to put the file into the modeling software, feed it into the machine, wait for the printing to be completed, and then remove the holder, polish, paint, and string it into a charm. Good responses were received from students (TMT-D20220116).
>
> Since the Lord Handan Festival takes place only in the city of Taitung, not all children have the experience of seeing it up close. Therefore, printing the model can help children understand the special festival in Taitung and then get a more concrete touch of it (TMV-E20220119).
>
> In addition, some teachers suggested that the model could be more "operational" in order to explain the abstract concept of an object:
>
> They may want a printable model to be able to show the functioning of the objects, so the modeled objects were not usually printed (THT-C20220116).
>
> The 3D-printed objects should ideally illustrate abstract concepts and present objects that they cannot see or touch (THB-A20220115).

In summary, this study was conducted to build an open-source database of Taitung's cultural contents, which were divided into five categories: cultural artifacts, local ecology, characteristic plants, characteristic architecture, and cultural celebrations. They were all digitally modeled and made available to the public for free download. The models of the 60 items constructed by six different instructors have four common results: (1) High visibility does make it easy to gain favor: e.g., Lyudao Lighthouse. (2) Those models with strong local characteristics are suitable for display and collection, including Paiwan ceramic pots, Paiwan hunting daggers, and Lyudao Lighthouse. (3) For novice 3D printers, objects in small sizes and which can be combined with other objects are more suitable. A good example would be ceramic beads which are not easy to fail in printing. During

printing, students can also learn about the meaning of the indigenous ceramic bead culture. (4) Animal models come with realistic details, such as wild boars.

Based on the analysis on the respondents' areas of expertise, life science teachers, who are familiar with 3D modeling and printing capabilities, preferred models with structural components that can function and explain cultural meanings, such as Lyudao Lighthouse, over monotypic models, such as plants and fish. The teachers of aboriginal culture and visual arts with a focus on the social and humanistic aspects agreed that digital models could help students understand the local cultural content in an innovative and interesting way. However, due to the limitations of 3D modeling and printing capabilities, they paid more attention to the printing time and ease of printing of models. As a result, the small sizes of models and the designs of the parts are key factors which affect the subsequent teaching and practical applications in the field of society and humanities. This echoes Nemorin and Selwyn, 2016 [30]; Leinonen, et. al., 2000 [31], Fahrurozi et. al., 2019 [32], Schelly et. al., 2015 [33], and Song, 2019 [34].

When reviewing the connection between cultural content and digitalization, it could be found that in 1998, the National Science and Technology Council (then Ministry of Science and Technology) launched the "Digital Museum Project (1998–2002)". This project aimed to build a digital museum with local characteristics and suitable for national conditions, establish a cooperative development mechanism and environment for digital museums in Taiwan, as well as train related technical personnel and develop related industries. This event is the beginning of the digitization of cultural contents in Taiwan.

In 2002, the Ministry of Science and Technology launched the "Taiwan e-Learning and Digital Archives Program" (2002–2007), which aims to digitize valuable tangible and intangible cultural assets Academia Sinica, National Museum of Natural Science, National Palace Museum, National Museum of History, and Academia Historica. Tangible artifacts are recorded by photography, festivals and rituals are recorded by video, and songs are recorded by audio. In 2008, the Ministry of Science and Technology advanced the implementation of the Taiwan e-Learning and Digital Archives Program (2008–2012) with the expectation of building a high-quality digital learning environment. The Ministry aimed to apply the collections to the educational field and industrial applications to shorten the digital gap between urban and rural areas. Today, after more than 20 years of digitization of cultural contents, technology, and devices for 3D printing have become popular and accessible to the general public. The trends of open-source sharing and the self-maker movement are irresistible in this era.

This study not only employed the previous digital image method but also presented images in 3D models so that users can understand the culture, history, architecture, sceneries, and folklore. The 3D models can also be used as a teaching tool for history and geography teaching in Taiwan's junior high schools and elementary schools, which are very convenient and practical, while driving the economy of 3D printing related industries. In addition, this study took Taitung as a case study. Through sharing with the general public, the innovative 3D digital open-source database was used as an inversion of the rural areas, spreading Taitung's unique charm and bringing innovative industrial energy to Taitung. On one hand, the local culture can be preserved, and on the other hand, the local cultural content can be expanded into various fields of education, research, and social development. A good use of technology and emerging thinking in the local culture will promote Taitung culture internationally. Tu [4] argued that the Taiwan government, academics, and industry may refer to DAPRA/NSF grants or EU sponsorships, and that more government and academic R&D results should be open-sourced to activate the community and the overall innovation force, which can reduce development costs and form a positive ecological cycle.

To sum up, this study explores the digital open source of local cultural content, and the results are as follows:

1. Among a large number of open-source objects, the digital model with high popularity and local distinctive features is like a signpost, which is conducive to attracting

attention to local cultural content and is suitable for users to print out for display or collection.

2. A building model designed in parts helps viewers understand the structure and features of the building more easily, and it is easier to succeed in 3D printing and assembling. Furthermore, ceramic beads with small size and various patterns are suitable for printing beginners as printing targets. They are not only easy to print successfully, but also can appreciate aboriginal culture and art.
3. In terms of subsequent teaching and practical applications, the printing time and ease of printing of models are still key factors in the digitization of local cultural content in terms of category selection and model design.
4. In terms of the audience served, the cultural content, which used to emphasize professionalism and precision and focused on academic research and education by many experts, can now be extended to any person in the world, and cultural views are open and free.
5. In terms of knowledge dissemination benefits, by breaking the boundaries of time and space, local cultural knowledge is no longer limited to local knowledge. Technology allows people who cannot visit the local area to see the Taitung cultural objects or even download and print them in real-time over the cloud platform to understand the details of the local cultural elements and their cultural connotations in a three-dimensional way. For the relatively remote Taitung, it is an innovative way to allow more people to learn the Taitung cultural contents and spread the benefits of intellectual property (IP).
6. In terms of the significance of cultural open source, in the past, local cultural contents were passively preserved and simply enjoyed or viewed, while open source is based on culture, allowing users to actively download and apply, and allowing users the freedom to adjust the size of the object to meet the needs of their own home environment. In this way, local cultural contents are truly used for education in life, with good cultural diffusion benefits and breadth.
7. In terms of information platforms, the previous collection platforms are all one-way browsing, where users need to go to a specific collection platform to view what they want. Nowadays, globally popular 3D model platforms are used, with complete systems, a higher number of enthusiasts, and easy-to-use interfaces. These platforms even provide such social functions as collections, comments, downloads, and sharing of users, showing higher interaction performance. Moreover, in the past, 3D modeling platforms mostly used figures, tools, and engineering parts as printing themes, but now, local cultural contents are used as digital modeling themes and to present innovative themes to the world.

5. Conclusions and Future Prospect

Local culture is a manifestation of people's life trajectory on the land. With the changing times, digital collections are not only digitizing traditional cultural relics but also have the mission of cultural connotation in horizontal and vertical inheritance. Digitization is seen as a "new way of organizing, structuring, and presenting knowledge". This study took Taitung as an example and proposed a model and operation process for open-sourcing local cultural contents. A total of 60 local digital models were built and displayed on two global open-source platforms, fully utilizing the function of local knowledge transfer without being restricted by geography. When resources are open and shared with the world, the chances of being noticed naturally increase. As more and more developers invest in the project, the first users can be established quickly, laying the foundation for the subsequent development of local culture digitization. With this as a model of reference, it is expected that all cities and towns in Taiwan will have their own localized 3D model database, so that the results of cultural digitization can be truly used and value-added, and local culture will no longer be just a collection of artifacts on the screen. Nowadays, 3D printers have become popular and mature in terms of hardware and technology. With

3D printers, everyone can simply print down the cultural contents in any place around the world at any time, enhancing the opportunity to know each land, enabling the public to use local culture, constructing a unique "local cultural digital experience", practicing the opportunity to make use of culture and truly breaking the gap between urban and rural areas. This study established an Object Information Cataloging Format to facilitate an effective understanding of the cultural meaning of objects and print information. It also created the first exclusive Taitung cultural content open-source database, expanding the concepts of digital manufacturing and open-source sharing from the engineering field to the cultural field. This study aims to extend the scope of local culture research and introduce new research perspectives in the field of cultural and creative industries.

The land of Taiwan is rich in diverse cultures and landscapes, and each city and town has its own cultural symbols and is known to the world with its unique geographical environment and humanities. The model proposed in this study can be applied to all cities and towns in Taiwan to collect the beautiful local culture of Taiwan through an innovative open-source platform, to spread the unique charm of remote villages through sharing, to design local industrial strategies, and to move towards cross-disciplinary knowledge integration of culture and technology. Through the open-source local digital model's characteristics of no geographical restrictions and free access, and particularly, under influence of COVID-19, even foreign people who cannot visit Taiwan in person can print local cultural contents remotely and understand Taiwan's cultural objects in a three-dimensional way, which will lead to the enhancement of local culture and the social atmosphere of local innovation and mutual benefit.

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Article

The Transformation and Application of Virtual and Reality in Creati A New Interpretation of the *Triadic Ballet*

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Abstract: Virtual imaging technology has been widely used in entertainment, medicine, engineering and other fields, and the advancement of virtual imaging has also provided new opportunities for art performances and exhibitions. This research uses live dance, screen dance and virtual dance displays to conduct the audience's experience of watching dance performances and compares the three forms. A total of 30 students participated in this research. According to the results of this study, the content of the dance works includes route and trajectory, movements and expressions, costumes, and overall atmosphere; there is no obvious difference under the three viewing conditions, and the spatial performance of dance works is best in live performances. According to the research results, the physical stage performance still has the advantage of space performance, virtual image has the advantage of solving the distance between the audience and the stage, and the screen image is helpful for the performance of the stage color. The results of this study show that the presentation of different technologies can improve the audience's viewing experience of dance, but how to create an impressive spatial experience using the screen image and a virtual environment for a live performance still needs technical improvement.

Keywords: virtual and reality; dance experience; creative dance teaching

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1. Introduction

Dance is one of the most primitive languages of human expression, one of the most memorable experiences in life, and one of the first and purest forms of bodily movement. Dance scholar Susan L. Foste proposed that choreography is a set of cultural codes created from postures and movements; choreographed body movements provide an embodied method of investigating the relationship between social structure and one's agency [1]. How audiences appreciate dance performances has always been a topic of discussion related to dance aesthetics [2]. Traditionally, dance performances were viewed in person in a theater; however, this involves highly complex tour arrangements for the dance troupe and transportation arrangements for the audience. During the COVID-19 pandemic, dance troupes could not tour, and audiences were required to maintain social distancing [3]. Consequently, many theaters were forced to close temporarily, posing an enormous challenge to the performing arts industry. In response, many theaters broadcasted dance performances online, and many artists broke through the barriers of traditional theaters by using digital technology to present dance performances to audiences. For example, the Cirque du Soleil used the online platform Cirque Connect to provide exclusive performance highlights to audiences. Audiences could also view performances on the Cirque du Soleil virtual reality (VR) app [4]. In addition, The Metropolitan Opera offered free Nightly Met Opera Streams on its official website [5], and the Vienna State Opera used Wiener Straatsoper to broadcast segments of performances for free [6]. When live performances are converted into broadcasted performances, performers, and audiences, despite experiencing the performance simultaneously and spending time together, are constantly aware that the other party is not physically present and thus lack the sense of sharing the moment with each other. This

phenomenon invites discussions on the concept of "liveness" in the performing arts and the reasons that live performing arts are irreplaceable [7].

The digital display of dance performances will inevitably continue due to factors such as technological advancement, the development of digital theaters, the arrival of the metaverse, and changes to how audiences enjoy performances following COVID-19. Further investigation and research are required to understand how the viewing experience of audiences changed as dance performances transitioned from the theater to the screen. Many studies have investigated the virtual display of art. For example, Chen [8] studied paintings displayed with various media and reported that viewing the original painting was perceived by audiences to be of the highest value and was preferred by audiences. Lin [9] compared paintings displayed physically, with desktop VR, and with head-mounted display (HMD) VR and discovered that the audience response did not differ substantially for these different display methods. Unlike the static display of a painting, dance is dynamic. Kyan et al. used the cave virtual reality environment to visualize dance moves, then used the VR images to train ballet moves. The results of the study showed that even non-professional dancers participating in training for the first time can achieve a 96% accuracy of movements through the system [10]. It can be seen that the virtual image is helpful for expressing the details of dance movements. It is worth mentioning that The Dutch National Ballet launched the first VR ballet *Night fall* in 2016. The audience's senses escaped from the traditional auditorium, and they can even decide where to focus in the VR world. Hiskemuller pointed out that choreographer Peter Leung and his dancers had to throw out all their previous working methods and habits [11]; the choreography process is not only based on dance movements, but also guides the audience with audio in the space, so that the audience can go deeper into the scene, and the virtual image can be seen. Technology has also changed the way choreography was traditionally done. Further investigation and research are required to understand the differences between live and digital virtual dance performances as audience experiences of dance are changed by technology that transcends time and space.

This study used the 2020 reconstruction of the famous *Triadic Ballet* of the Bauhaus theater as a case study. The performance premiered in Germany in 1926 and was created by Bauhaus artist Oskar Schlemmer (1888–1943); it is now considered a representative work of contemporary art. It explored the concept of humans and spaces, presented the mathematics of body motion in space, and created a sense of three-dimensionality to the stage. Schlemmer sought a new form of stage through his experimentation with mechanical motions and abstract stages. Consequently, the *Triadic Ballet* has been praised as a prophetic movement of contemporary virtual stage spaces [12]. Thus, the *Triadic Ballet* was employed as a case study for investigating the properties of live and virtual performances.

1.1. Application of Virtual Images in the Performing Arts

The earliest performance with virtual images can be traced back to 1858, when scientist Henry Dircks (1806–1873) first proposed using projections for theater performances. Later, the Director of the Royal Polytechnic Institution, John Henry Pepper (1821–1900), created the projection technique Pepper's ghost, which was widely adopted in theaters [13]. Pepper's ghost was produced by using light and glass to reflect an object in a dark space to simulate a virtual ghost that could be interacted with by live performers. Although holographic technology has improved, Pepper's ghost is still a common technique, through reproduction and adaptation, to produce virtual images in museums, amusement parks, and theater stages [14]. In 2010, Japanese music software company Crypton Future Media developed a virtual female singer, Hatsune Miku. Pepper's ghost and holographic technology were used to produce a concert with a dynamic image of Hatsune Miku displayed on stage. Some members of participating audiences began to believe that she actually existed [15]. In a 2011 performance of *The Beauty and the Beast*, directed by Canadian directors Michel Lemieux and Victor Pilon, Pepper's ghost was used to create a virtual image of the young Beast on the stage to increase audience immersion in the performance [16]. In

the contemporary stage production *Urbik/Orbik*, created by French director Joris Mathieu, virtual images created with Pepper's ghost [17] were used to create a hybrid of real and virtual performances. Similarly, augmented reality (AR) and VR performances have also been produced. Israeli theater artist Sasha Kreindlin used AR technology in a children's show adaptation of *Gulliver's Travels* [18] to create an immersive experience for audiences. The Bauhaus Museum in Germany displayed a VR exhibition, *Das Totale Tanztheate* [19], to commemorate the museum's centennial; the exhibition was designed based on the theatric concepts of Schlemmer. The exhibition displayed virtual images created with a combination of VR and motion capture technology. Audiences wore HMD VR devices to create an immersive experience that caused them to feel like they were physically and emotionally present in the digitalized Bauhaus theater. Herscher et al. studied the feelings of audiences after they watched movies in the cinema or with a VR device [20]. They reported that, although VR devices could increase immersion and help audiences engage in the plot, the collective interaction of the audience with the movie plot in the cinemas could not be replicated by VR devices. Bender used psychophysiological methodologies, such as skin conductance level, facial electromyography, and other biometric responses, to measure the physiological responses of audiences watching VR movies. The results demonstrated that VR devices could increase audience excitement [21].

1.2. The Application of Digital Virtual Images in Dance

Digital technology is becoming increasingly common in modern life, and people are becoming more accepting of participation and interaction using digital technology. However, applications of digital technology in dance are still limited. Art such as movies, photography, and music rely on digital technology to some extent, but dance has remained analog because dance requires actual movements of the body. Postmodern dancer Loïe Fuller experimented with applying technology to dance by combining video projections and shadow effects to change her silhouette. She even created dance performances in which her costume glowed. Light rays have been manipulated to extend space and transcend the silhouette of dancers and their visual presentation [7]. *Light Plays* (1923) by Schlemmer combined human forms, shadow effects, and projections and was a pioneering explorative work of technological performance. During the 1920s, Schlemmer brought the abstraction of narrative, space, and dance to a pinnacle [22]. Multimedia performance company Troika Ranch developed software for dancers; the software could play and manipulate the captured live and prerecorded images in a dance performance. One of the lead developers of the software, Mark Coniglio, described the importance of "impossible instructions" to dancers and their experience with the instructions in the creation of new digital performances. Coniglio believed that current technology is insufficiently sensitive to human postures and the properties of human motion [23]. Rosenberg explained that the transfer of space and kinetic energy is becoming digitalized due to the development of multimedia technologies. Many types of dance performances have appeared, and applications of digital technology in dance have increased to include video dance, motion capture, VR, and network interactions [24].

While investigating applications of virtual dance images in the 1950s, American choreographer Alwin Nikolais (1912–1993) projected hand-painted slides onto the bodies of dancers on stage in an attempt to create a space where virtual images interacted with reality. Subsequently, numerous choreographers began attempting interactive projection [25]. The first three-dimensional documentary about dance, *Pina*, was directed by director Wim Wenders for the greatest dancer in the 20th century, Pina Bauch (1940–2009). Dances and body motions in movies are often enhanced or exaggerated through visual presentation techniques. Using a multidimensional lens can enhance the expression of body motions and the space of the stage [26]. Directors use three-dimensional images to connect audiences, who sit in front of the screen, with the theater presented in the movie to create the illusion of them being in a real theater, extending the theater out of the screen into reality. This change in perspective liberated audiences from remaining in a fixed location in the theater and

truly engaged audiences in the dance performance, which realized the idea of an extended theater [27]. The transition from the theater to the screen represents the interaction between real and virtual space; the border between the two becomes blurred, and screens and the Internet are becoming the new theater and creating new spectatorship [28]. Chin used moving screens as cues and used the interaction between screens and stages as an architecture for interpreting the unique phenomenon of contemporary spectatorship. Mobile technology has provided audiences with new methods of viewing performances and providing feedback [29]. Unlike conventional theaters, in which virtual text is viewed as a projection from another world, environmental simulations in contemporary VR break though the mimetic mindset of conventional art and form a self-sufficient world of their own. That is, the simulated world is no longer a replica or reference of the real world and has its own purposes [30].

1.3. Perceptions of Digital Audiences Viewing Dance

When the theater serves as an organism that mediates audiences and performances, the manner in which audiences view and perceive performances is affected by the format and medium of these performances. In conventional theaters, audiences are immersed and project themselves onto the fictional plot. Their minds become inseparable from the performance. After digital virtual technology was introduced to theaters, audiences began to use their sensations to experience the world that they perceived and imagined. A study [31] identified two types of immersion: Immersion in conventional theaters: although audiences in conventional theaters typically viewed performances passively, the extent of their immersion depended on whether they could actively enter the fictional alternative space and forget where they actually were. VR immersion: sensory-oriented VR digital theaters focus on materiality and physical sensations, breaking the boundaries between the "inside" and "outside" of the performance, enabling audiences to connect their internal and external sensory experiences.

Studies on theater audiences often focus on binary debates, such as virtual or real, prerecorded or live, or two- or three-dimensional. They frequently lament how the precious "liveness" of theaters is lost in videos [32]. Phelan argued that the life of performances was ephemeral, existing only in the moment. Performances could not be truly stored, recorded, documented, or redisplayed; these actions would convert a performance to something else [33]. Theater scholar Philip Auslander stated that the concept of liveness appeared after the emergence of video recording technology, that images displayed on screens also have the power to influence audiences, and that images and stages affect each other cyclically instead of cancelling each other out [34]. Sigrid Merx was optimistic about video recording and media usage and stated that these methods did not displace live performances [35]. Greg Giesekam reported that, since the start of the 20th century, both movies and stages have cooperated closely. Instead of destroying liveness, screens enhanced it [36]. Although the actual space and distance between performers and audiences increased, the spatial barrier was reduced due to interactive communication. Audiences also appear in the performance space and have importance equal to the performers. Moreover, audiences can share more of the experience than in a conventional performing environment because they are visible participants or performers themselves to some extent. Steve Dixon used three dimensions, namely, body, space, and time, to investigate changes in the performing arts and digital theaters and how the spatial perception of audiences was extended to create an immersive and dynamic theater set design. The special spatiotemporal perception of the set changed the perceptions of performers and of audiences. Conventional performing arts have been thought to require a collective response (for example, the audience looks in the same direction as a single entity). This concept is being consistently challenged by digital technology [7,22]. During the digitalization of performances, the viewing behaviors of audiences have been reexamined in terms of the viewing experiences of individuals. Audiences are encouraged to become a part of an art performance. In technological theatric performances, the perspective of an "experiential experience" was taken to focus on how

audiences imagine and reflect on the purpose of artworks and how interactions occur between multiple texts [37].

1.4. Purpose

Performing arts have a characteristic liveness. Scholars have debated whether the COVID-19 pandemic has changed the lifestyles of audiences and their performance viewing habits and have yet to reach a conclusion. Online videos and virtual dances provided by dance troupes have given audiences a novel perspective for viewing performances and, with the advent of the metaverse, have accelerated the development of virtual technology in dance. Studies have investigated how audiences viewed performances with various media in museum exhibitions, painting exhibitions, and cinemas. However, little research has been conducted on dance performances experienced through different media formats. Studies have investigated the perception of audiences viewing digital dance performances; however, these studies were subjective. Therefore, this study investigated which of the following formats best enhanced audiences' resonance with or perception of dance performances: live performances, screen images, and virtual images. Moreover, some suggestions for creators of screen image dances and virtual image dances are provided.

2. Materials and Methods

2.1. The Dance Work

The research sample consisted of audiences of the renowned dynamic art performance, the *Triadic Ballet*, of the Bauhaus theater, which was reproduced by our research team (see Figure 1) [38]. The *Triadic Ballet* premiered in 1922 and was created by Schlemmer [39]. The *Triadic Ballet* is the most famous work of Bauhaus artist Schlemmer. Its performance in color, shape, and space is quite modernist. Our team reconstructed this work, using the manuscripts and diaries left by Schlemmer to create costumes and movement, and promoted this work to a senior high school and a University for performances in art education promotion activities (see Figure 2). A total of 334 students appreciated this work, the average score of preference for the work is 4.18 points (out of 5 points), which shows that, even after 100 years, this work is still accepted by modern audiences. The ballet was an experiment on the relationship between the human body and space. The rigid and mechanical dance motions of the actors in costumes and masks challenged perceptions of the integration between modern technology and dance performances and stimulated reflection on the coexistence between reality and virtuality [40]. Schlemmer once said that the emergence of new forms of theaters is just a matter of time, technology, and materials [41]. Therefore, the *Triadic Ballet* was used to investigate how the audience felt when they viewed live performances, screen images, and virtual images. The dance performance was divided into three acts named *Yellow*, *Rose*, and *Black*. The duration of each act was approximately 1 min and 20 s. The total duration of the performance, including intermissions, was 5 min.

Figure 1. Reproduction of the *Triadic Ballet*. (Source: Reprinted with permission from [34]. Copyright 2011 Ting, I.-W. et al.).

Figure 2. *Triadic Ballet* educational promotion and performance activities. (Source: this study).

2.2. Participants

In order to gain a deeper understanding of the differences in different performance forms, this study selected college students with artistic backgrounds to participate in this experiment, in order to reduce the general audience's cognitive difference of artistic works. A total of 30 art university students participated in the experiment: 8 were men (26.7%) and 22 were women (73.3%). Their average age was 20.2 years (SD = 0.817). The average self-evaluation scores of the participants for their understanding of Bauhaus and Bauhaus theater were 3.3 and 2.9, respectively (1 indicated that the participant knew little about Bauhaus, and 5 indicated a comprehensive understanding). Overall, fifteen participants reported preferring live performances (50%), thirteen preferred virtual images (43.3%), and two preferred screen images (6.7%).

2.3. Experimental Design

2.3.1. Independent Variables

The independent variable in the experiment was the format of the *Triadic Ballet*: live performance on stage, screen images, and virtual images.

The formats are as follows:

- Live performance. The live performance was performed on the stage of a professional theater. On the day before the experiment, lighting, flooring, and audio were installed. A colorful background was projected on the cyclorama with a 6000-lumen laser projector (PT-MZ670A; Panasonic, China); the dancers performed a full rehearsal on the stage. On the day of the experiment, the dancers performed the three solo dance acts: first *Yellow*, second *Rose*, and third *Black* (see Figure 3).

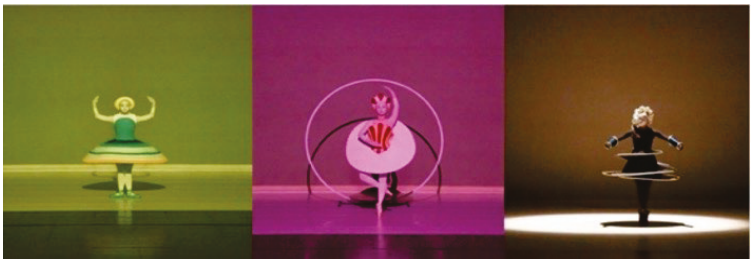

Figure 3. Live performance. (Source: this study).

- Screen images. To produce the screen images, the dances were filmed and recorded in a virtual studio. Motion was also filmed and captured in front of a green screen for constant-color matting. After the images were recorded, the image editing software Adobe After Effects was used for image matting. The final images were displayed using a 36-inch vertical television (TL-32LE60; Chimei, Taiwan) (see Figure 4).

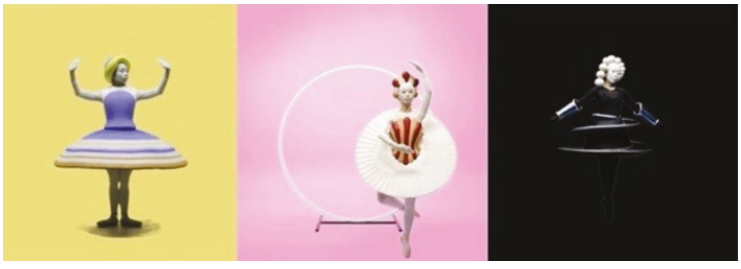

Figure 4. Screen performance. (Source: this study).

- Virtual image. The virtual images were created in our previous study [34]. Images based on Pepper's ghost were used because it was the first method of producing virtual images in theatric performances to enable interactions between live performers and virtual ghosts (see Figure 5). In order to reduce the blue light generated by the glass projection, when making the projection black box, the background color of each dance was painted in the black box, the dance video adopted the image of removing the back, and small lamps with an adjustable light source were used to adjust the display black box according to the intensity of the on-site light at the exhibition site light source to present the most suitable brightness for viewing.

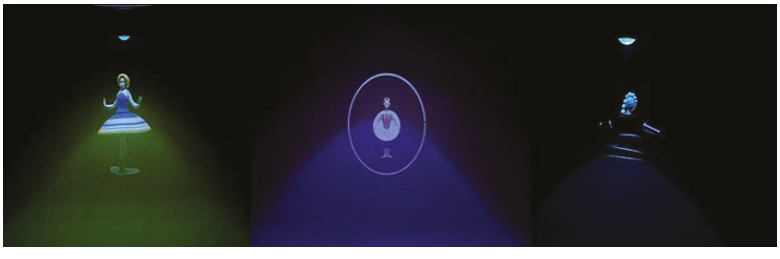

Figure 5. Virtual performance. (Source: this study).

2.3.2. Dependent Variables

The dependent variables of this study were the participants' perceptions of a performance (see Table 1), as indicated by the results of a questionnaire survey. Participants first rated the dance performance content, including route and trajectory, movements and expressions, costumes, and overall atmosphere. Second, they rated the dance performance space (depth, width, height), including dance movements, overall costume styles, and overall dance style. Third, the participants selected their favorite dance and format.

2.4. Research Hypothesis

According to the purpose of this study, the research hypotheses are as follows: 1. The dance performance content has significant differences in different forms of expression. 2. There is no significant correlation between the dance performance content. 3. The dance performance space has significant differences in different forms of performance. 4. There is no significant correlation with the dance performance space.

Table 1. Questionnaire of dependent variables.

Part		Item
Part 1	dance performance content	1. route and trajectory 2. movements and expressions 3. costumes 4. overall atmosphere
Part 2	dance performance space (depth, width, height)	1. dance movements 2. overall costume style 3. overall dance style
Part 3	favorite dance	1. *yellow* 2. *rose* 3. *black*
	favorite format	1. live dance 2. screen dance 3. virtual dance

Source: this study.

2.5. Experiment Procedure

The experimental procedure was divided into three stages. The first stage was the preparation stage, in which the researchers explained the purpose and procedure of the experiment to the subjects. The second stage was the experiment. The participants viewed the different formats of the performance in a random order in accordance with instructions from the administrators. They viewed a live performance, a televised performance, and a virtual performance (see Figure 6). In order to avoid the problems of viewing fatigue and learning effect among the 30 subjects in this study, as well as to avoid the unpredictable situation of the stage and dancers during the live performance, which could cause confounding variables, the subjects were randomly assigned. There were six groups with five people in each group, and the start time and viewing form order of each group were adjusted so that each group watched the live performance at the same time; the detailed grouping is shown in Table 2.

Figure 6. The viewing situation of live dance, virtual dance, and screen dance. (Source: this study).

The participants did not wear VR devices, to avoid the experience of wearing an HMD affecting their feedback. After viewing the performances, they completed a questionnaire for that format and returned it to an administrator. The participants were not required to complete the questionnaire within a specific time. In the third stage, the participants returned their folders with completed questionnaires and the number tags used for the experiment. Finally, they provided demographic data and reported their overall viewing experience on the final questionnaire.

Table 2. Audience grouping order.

Group	Group	1	2	3	4	5	6
	Number	**1–5**	**6–10**	**11–15**	**16–20**	**21–25**	**26–30**
Time	10:40			3			1
	10:50	1			3		
	11:00			1			3
	11:20	2	2	2	2	2	2
	11:30	3				1	
	11:40		3		1		
	11:50		1			3	
Viewing form: 1 = Screen dance, 2 = Live dance, 3 = Virtual dance							

3. Results

3.1. Format and Dance Content Perceptions

The goal of this study was to understand whether perceptions of dance content were affected by dance format. The ANOVA analysis reveals that format did not significantly affect perceptions of dance content for any of the questionnaire elements. Although the differences were nonsignificant, the average scores for the live performances were strictly greater than those for the screen or virtual performances; except for screen images presented for *Black*, the average scores of route and trajectory, costume color are greater than other formats. Therefore, bright-colored costumes were preferred in virtual images and black costumes were preferred in screen images.

3.2. Correlations between Dance Content Items

A correlation analysis was used to further investigate the relationships between dance choreography, movements, costume colors, and overall atmosphere (see Tables 3–5). Significant and positive correlations were observed in *Yellow* for witty movements and expressions with a humorous dance atmosphere and in *Rose* for stern movements and expressions with a humorous dance atmosphere. Hence, both choreography and atmosphere affect audiences' perceptions of dance.

Table 3. Correlation analysis: *Yellow*.

	Item	1	2	3	4
yellow	1. Rectangular route and trajectory	-			
	2. Witty movements and expressions	0.445 **	-		
	3. Splendid costume colors	0.236 *	0.338 **	-	
	4. Humorous dance atmosphere	0.298 **	0.739 **	0.302 **	-

* $p < 0.05$, ** $p < 0.01$.

Table 4. Correlation analysis: *Rose*.

	Item	1	2	3	4
rose	1. Triangular route and trajectory	-			
	2. Stern movements and expressions	0.558 **	-		
	3. Grand costume colors	0.409 **	0.577 **	-	
	4. Solemn dance atmosphere	0.450 **	0.685 **	0.678 **	-

** $p < 0.01$.

Table 5. Correlation analysis: *Black*.

	Item	1	2	3	4
black	1. Circular route and trajectory	-			
	2. Magical movements and expressions	0.429 **	-		
	3. Steady costume colors	0.290 **	0.231 *	-	
	4. Mysterious dance atmosphere	0.313 **	0.342 **	0.463 **	-

* $p < 0.05$, ** $p < 0.01$.

3.3. Format and Dance Space Perceptions

The results in Table 6 demonstrate that the spatial width of dance movements, the spatial width of the overall costume style, and overall spatial depth were significantly greater for the live performance than for the other formats. Overall, the average scores for dance movement and overall costume style were highest for live performances and lowest for screen images, which were attributed to the limited visual areas of the screens, reducing audience perceptions of the spatial width of movements and styles. Moreover, the spatial depth scores were highest for virtual images and lowest for screen images.

Table 6. ANOVA analysis of expression of space.

Subjective Questionnaire (1–5 Points)	Format			
	Live Performance	Screen Image	Virtual Image	Sig.
1. The dance movements had changes in the spatial depth	4.33	3.83	4.10	
2. The dance movements had changes in the spatial width	4.17	3.47	3.77	**
3. The dance movements had changes in the spatial height	3.47	2.87	3.13	
4.The overall costume style presented spatial depth	3.80	3.73	3.97	
5. The overall costume style presented spatial width	4.07	3.53	3.80	**
6. The overall costume style presented spatial height	3.53	3.33	3.30	
7. The overall dance presented spatial depth	4.23	3.73	4.30	**
8. The overall dance presented spatial width	4.23	3.63	3.90	
9. The overall dance presented spatial height	3.47	3.07	3.20	

** $p < 0.01$.

Audience perceptions of depth may differ depending on their distances from the performances; audiences in the virtual space may have been able to better observe changes in the depth of the dance movements than some live audience members.

3.4. Correlations between Spatial Expression Items

Table 7 reveals that all nine spatial expression factors were significantly correlated. Therefore, although space is an abstract concept, dance movements and costume styles that effectively express space result in an effective expression of space in the overall dance, reinforcing audience perceptions.

Table 7. The correlation analysis of the items of the expression of space.

Variable	1	2	3	4	5	6	7	8	9
1. The dance movements had changes in spatial depth	-								
2. The dance movements had changes in spatial width	0.582 **	-							
3. The dance movements had changes in spatial height	0.425 **	0.622 **	-						
4. The overall costume style presented spatial depth	0.550 **	0.337 **	0.396 **	-					
5. The overall costume style presented spatial width	0.355 **	0.578 **	0.392 **	0.385 **	-				

Table 7. *Cont.*

Variable	1	2	3	4	5	6	7	8	9
6. The overall costume style presented spatial height	0.282 **	0.480 **	0.611 **	0.397 **	0.587 **	-			
7. The overall dance presented spatial depth	0.590 **	0.405 **	0.276 **	0.513 **	0.408 **	0.245 *	-		
8. The overall dance presented spatial width	0.387 **	0.616 **	0.498 **	0.371 **	0.621 **	0.522 **	0.565 **	-	
9. The overall dance presented spatial height	0.272 **	0.465 **	0.700 **	0.273 **	0.436 **	0.640 **	0.264 *	0.679 **	-

* $p < 0.05$, ** $p < 0.01$.

3.5. Favorite Dance

The chi-squared test was used to investigate audience preferences for the three dance performances in various formats (see Table 8).

Table 8. Chi-squared test for favorite dance.

Independent Variable			Items			χ^2	df
			yellow	*rose*	*black*		
Format	Live performance (n = 30)	f	10	7	13	1.8	2
		%	28.6	25.0	46.4		
	Screen image (n = 30)	f	14	7	9	2.6	2
		%	48.4	22.6	29.0		
	Virtual image (n = 30)	f	11	4	15	6.2 *	2
		%	36.7	13.3	50.0		

* $p < 0.05$.

Virtual and live viewers both preferred the *Black* dance, whereas screen viewers preferred the *Yellow* dance. *Rose* was the lowest-rated for all formats. These results indicate that virtual images may enhance the "mysterious" atmosphere of the *Black* dance for audiences, and bright colors may be preferable for screen viewers.

4. Discussion

In this study, the audience perceptions of the *Triadic Ballet*, a Bauhaus theater performance, in various formats, namely, live performances, virtual images, and screen images, were investigated. The research results suggest the following conclusions.

4.1. Superiority of Live Performance

The *Triadic Ballet* was a spatial interpretation experiment by Schlemmer. Through dance performances, the trajectory of the human body, costumes, and spatial colors can be observed. The results indicate that audiences prefer the *Triadic Ballet* as a live performance. Spatial width perceptions of the items "dance movement," "overall style," and "overall stage" were greater for live performances than for on-screen or virtual performances.

4.2. Modern Technology as an Alternative to Different Formats of Performances

Modern technology has enabled audiences to view performing arts in diverse formats and perspectives, including conventional screen images and virtual, 3D images. In this study, the Pepper's ghost effect was used to create a simple virtual image device for displaying the *Triadic Ballet*. Audiences gave the highest ratings for depth to this virtual performance, indicating simple virtual devices could be superior to live and on-screen performances for certain spatial perceptions of *Triadic Ballet* audiences.

4.3. Differences in Viewing Media

In art appreciation, audience ratings and preferences differing between performances are normal. These preferences could also differ for the same performance presented using different media. This study performed a correspondence analysis for the three dance performances and the three formats: live performance and virtual image audiences rated the third performance *Black* the highest, whereas screen audiences preferred and rated the first performance *Yellow* the highest. The intention of Schlemmer (to interpret space) was best achieved by live performances and virtual images; however, screens could be used for specific units of the performance.

4.4. Blending Cognition and Emotion

Bauhaus has long been studied due to its impact on contemporary design, but Bauhaus theater, particularly the *Triadic Ballet* of Schlemmer, is often overlooked and is rarely discussed. The study participants knew little about Bauhaus; however, their ratings of choreography, movement and expression, costume color, and dance atmosphere were highly correlated, and the dance movement, overall style, and overall dance were significantly correlated in terms of spatial expression. These results demonstrate that, if creators adequately arrange and present their creative concepts, audience cognition and appreciation of the performance can be improved.

4.5. Audience Perceptions of Different Media Representations

From the literature, we can see that many discussions on the application of virtual technology in performances mostly focus on how the characters can be displayed through virtual technology, so that the audience can go deeper into the scene and integrate into the development of the plot. The audiences in this study analyzed the differences in viewing cognition through the non-dramatic performance of the *Triadic Ballet*, and we integrated the literature analysis and the results of this study. In addition to enhancing the audience's deep feeling of the plot, virtual image technology can also be used in Minimal Art, increasing the audience's display of dance movements and the overall performance in its details. The audience members' interaction with other members of the audience in the real theater, and the emotions reflected by the audience following the dancers' performance, such as tension, excitement, and joy and sorrow, are the advantages of live performances, which cannot be achieved or replaced by other technologies.

5. Conclusions and Suggestions

5.1. Conclusions

Performing arts have been discussing the issue of live performances for a long time, However, with the development of virtual technology and the rise of the metaverse, the viewing logic of audiences watching live performances has also changed; how to convey the characteristics of dance works through appropriate performance forms helps the audience obtain a good viewing experience. This study verifies the effects of different performance forms through appropriate research and understands the characteristics and differences of live performances, screen images, and virtual images. Among the three forms, the sense of space in live performances cannot be replaced by other imaging technologies; however, with virtual images, the excellent performance in the depth of space helps to solve the problem of the viewing distance between the audience and the stage in real theaters. Although the frame of the screen image limits the audience's perception of space, better color perception is achieved with the screen image. The results of this study provide a reference for choreographers when designing the expression form of works in the future and help to enhance the audience's viewing experience and cognition of the work. How to display the sense of space created by real dancers through movement performance and costume modeling in virtual images and screen images is also worthy of further development of related technologies.

It is worth mentioning that, as virtual technology becomes more mature, audiences will have more choices in the way they watch dances in the future. Therefore, when artists create dance works, should art precede technology or technology precede art? How to maintain the uniqueness of artistic creation will be an issue worthy of in-depth discussion in the future. According to the results of this study, when the dance company displays dance works on the Internet or other media, it is no longer applicable to directly use the video records of stage performances in the past. When presenting dance works in different media in the future, the characteristics of the display media should be considered. If choreographers focus on the details of dance works, using virtual image display can be considered. If choreographers focus on the color design and stage design works, screen displays can be used. If choreographers focus on the relationship between dancers and space in dance works, it is still recommended to use live performances on the stage. Only by making good use of the characteristics of different display forms can the characteristics of the work be properly presented to the audience, so as to improve the audience's cognition of the work and its viewing experience.

5.2. Suggestions

This study has a few limitations. First, the modern performance of the *Triadic Ballet* was used; the cognition and understanding of audiences could differ for other dance styles. Second, the research subjects were art university students, and the results may not be applicable to general audiences. Third, the small sample size of 30 participants may be insufficient to draw general conclusions.

A Pepper's ghost effect was used to produce the virtual dance performances in this study; however, various virtual images can now be created with modern technology. As digital technology advances, it increasingly affects the display of the performing arts. A century ago, Schlemmer used the prospective performance of the *Triadic Ballet* of the Bauhaus theater to predict the future of performing arts. Interdisciplinary cooperation between technology and art can inspire new forms of creative expressions and expand the study of art and technology.

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Article

The Global Design Ranking: A Case Study of Design Awards Phenomenon

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Abstract: This study explored two issues: (1) could the number of design awards represent the design level of a country? (2) If the design award is not suitable as criterion, is there a more appropriate one(s)? Beginning with the phenomenon that use the number of design awards as a benchmark for evaluating national design capabilities, its rationality through objective data is examined. The research reviews the existing mechanisms and attempts to establish a more comprehensive one through expert interviews and questionnaires. Six criteria were identified: international activity, designers' level, future trends, historical impact, lifestyle taste, and environment standards. When these criteria are used to evaluate a country's design level, the results are in line with the overall impression of design experts. Conversely, the framework based on the number of design awards leads to a significant gap. The results overturn the evaluation systems of design awards. In terms of academic contribution, through the establishment of a new mechanism, the lack of existing ones can be made up. In terms of practical implication, design stakeholders in various countries have a benchmark for inspection when trying to improve their design level or international reputation. The research provides reference for policy formulation and strategy development.

Keywords: design award; national design power; design ranking; Taiwan design

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1. Introduction

1.1. "Design Awards Phenomenon" in Taiwan

In the past few years, Taiwan has ranked among the top in the number of awards received in major international design awards. This small island with only more than 20 million people and located on the edge of East Asia has experienced the stigma era of "Pirate Kingdom", and then it has achieved the international reputation of MIT ("made in Taiwan") with its strong manufacturing and OEM capabilities.

In recent years, with the injection of government resources, the implementation of relevant policies, and the concerted efforts of private enterprises and academic institutions, Taiwan is committed to investment in design. Continuous talent training, diverse and frequent design activities/exhibitions/ forums, and active participation in international awards, etc., Taiwan has made great efforts to improve its own design level and international visibility in the past few years. In the end, Taiwan was recognized for many design awards, and the international reputation of "DIT (design in Taiwan)" was gradually established.

The official promoter of Taiwan's design industry, the Taiwan Design Center, held the first International Design Alliance (IDA) conference in 2011, and then successfully assisted Taipei city to be selected as the WDC (world design capital) in 2016. In 2020, the Taiwan Design Center was transformed to become the Taiwan Design Research Institute, expanding the design application level to the governments, schools, transportation, and other aspects.

In recent years, Taiwan has achieved the benefits of substantive diplomacy by participating in international organizations and enhancing its international visibility through

design. Years of hard work, cumulative investment of manpower, time, and resources are quite considerable, and some benchmarks are bound to be used for effectiveness evaluation.

How should one evaluate the results of Taiwan's investment in design? Has the overall design level improved? How do other countries rate Taiwanese design? These issues are not easy to be qualitatively stated clearly. The design awards provide a benchmark for quantitative verification, and they have international visibility, credibility, and influence. They just meet such evaluation needs and provide the most direct and convenient solution.

Generally speaking, the operation of the design award is roughly as follows: (1) obtain as many entries as possible and select relatively high-quality designs that meet the requirements of the design award. (2) Through the award, the design concept that the organizer wants to convey is demonstrated. (3) Through a large number of registrations, directly or indirectly obtaining operating expenses, or tangible or intangible assets (such as the production rights of the winning design), the design award can be attained.

Taiwan's internal market is small, and export sales have become an important lifeline of the economy. Therefore, international recognition has long been the goal of Taiwan's active efforts. For example: MIT has become an international recognition of the quality of Taiwan's manufacturing and is an important asset for Taiwan's exports.

The same is true in design. Design mainly originated and emerged in European countries and the USA; in Asia, Japan was one of the earlier countries that entered the era of modern design. As a late follower, Taiwan learns design from the aforementioned leading countries. Therefore, when evaluating the achievements and growth of these years, it is natural to look for international perspectives as a basis. It is an inevitable and convenient choice to use the number of international design awards as the benchmark for Taiwan's investment in design. The large number of entries from Taiwan also coincided with the operational goals of these design awards.

Among the many international design awards, Taiwan is most actively involved in the following four: "iF Design Award (hereinafter referred to as "iF")", "Reddot Design Award (hereinafter referred to as "Reddot")", "Good Design Award (hereinafter referred to as "G Mark")", and "International Design Excellence Award (hereinafter referred to as "IDEA")". According to a public speech by the President of Taiwan, the number of the four major design awards won was not many at the beginning (only 16 in 2003), but by 2018, Taiwan has won a total of 3825, including 142 first prizes or gold awards. This splendid figure has become a concrete manifestation of Taiwan's strong "design power" [1].

According to "Taiwan Design Power Report 2019", the fastest way for Taiwan's design industry to gain recognition is to enhance "company reputation" and obtain "free publicity" through international design awards. Up to 84.1% of design practitioners have participated in the International Design Awards, and 1/5 of them participate regularly every year [2].

1.2. World Design Ranking (WDR)

Countries could be ranked according to their economic and military power, but can "design power" be ranked? If so, what criteria should be used to evaluate it?

According to the "World Design Ranking (WDR)", published by the Italian A' Design Award (hereinafter referred to as A'), Taiwan ranks 7th in the world, and the top six are China, USA, Japan, Italy, Hong Kong, and the UK. Germany, Spain, Netherlands, Switzerland, Finland, France, and Sweden, which are generally recognized as leading design countries and possess world-class design masters, lag behind Taiwan in this ranking, ranging from 9th to 37th, and Denmark ranks only astonishingly at 61st [3].

Similar rankings have been launched in various design awards, and Taiwan has achieved quite impressive results. The excellent performance of the international design awards has become an important achievement in the design policy of the local government. A public research report by the Taiwan Design Institute, a semi-official design promotion organization, cited WDR as proof of Taiwan's leap in "design power" [4]. The local academic community also attaches great importance to the number of design awards, and has listed them as key evaluation standards for design schools and professors.

However, is Taiwan really such a leader in international design rankings? Is it ahead of many recognized design-leading countries? Or, to put it another way, is it appropriate to use these design awards as a benchmark for evaluating a country's "design power"? Does it reflect and match real-world perceptions?

Perhaps it is because of the credibility of the design awards, or complex factors such as politics and interests, that related discussions or questions are rarely seen in research papers. For global design rankings, especially for country-specific rankings, it is difficult to find comparable and influential benchmarks other than WDR. The lack of related mechanisms has left a lot of space for academic research, which has also become the motivation for this research.

This study attempts to establish a country-based design level evaluation mechanism. It is hoped that this attempt will inspire more design scholars, practitioners, and policy makers to further discuss and participate in dialogue so that future mechanisms can be developed more comprehensively.

When the number of design awards is used as a way to evaluate the design level of a collective unit (such as a school, a company, or a country), and participation in design awards also becomes a collective craze, this study calls such a situation the "Design Award Phenomenon", and the suitability of this phenomenon is questioned.

Through this study, it is expected that a more macroscopic, comprehensive, and rigorous evaluation system can be established.

2. Materials and Methods

2.1. The Definitions of Good Design

How is "Good Design" defined? This topic has been of great interest to design research scholars for a long time, but it is expressed individually, full of various arguments, viewpoints, and guidelines. For example, the "Form Follows Function" proposed by Bauhaus school architect Louis Sullivan, who laid the foundation for modern design, is still the guiding principle that many designers hold as the standard. In the late 1970s, design guru Dieter Rams thought of: "Good design is subjective and can't necessarily be measured." But he still tried to come up with the famous "10 Principles of Good Design", which defines "Good Design" must fulfill the criteria "Innovative", "Useful", "Aesthetic", "Understandable", "Unobtrusive", "Honest", "Long-lasting", "Thorough down to the last detail", "Environmentally-friendly", "As little design as possible". These principles have become iconic and keep inspiring designers around the world [5].

However, there are still different arguments for the definition of "Good Design". Steve Jobs also tried to give his opinion on this: "Design isn't just what it looks like and feels like—design is how it works" [6]. His views on good design tend to be more pragmatic.

Some scholars put forward: "the most important design elements are those that cannot be specified by a standard". Many designs that are considered "important" and "good" are often overlooked by standards to evaluate designs because of their beauty [7]. Jared Spool, expert on design and usability, echoes this statement: "good design, when it's done well, becomes invisible. It's only when it's done poorly that we notice it." This is why good design is tricky to define [8].

Over time, there have been guidelines developed for various design fields. For example: in 1997, a group of architects, product designers, engineers, environmental designers, research scholars, etc. led by Ronald Mace in the North Carolina State University initiated "the 7 principles of universal design". These principles are: "Equitable Use", "Flexibility in Use", "Simple and Intuitive Use", "Perceptible Information", "Tolerance for Error", "Low Physical Effort", and "Size and Space for Approach and Use". These guidelines are designed to incorporate more care and empathy for people and the environment [9].

In the other example, Jakob Nielsen proposed "10 usability heuristics for user interface design", which is a design principle formulated in response to human–computer interaction in modern design. The ten principles mentioned in this argument are: "Visibility of system status", "Match between system and the real world", "Consistency and standards", "Error prevention", "Recognition rather than recall", "Flexibility and efficiency of use", "Aes-

thetic and minimalist design", "Aesthetic and minimalist design", "Help users recognize, diagnose, and recover from errors", and "Help and documentation".

These design principles are more specific than Dieter Rams' argument. They are formulated according to the specific design field, and they are more inclined to the design execution [7].

How do you rate "good design"? It has always been a controversial issue, and the focus is not whether it should be evaluated, but what kind of "standard" should be used [10] (Lin, 2007). However, it is precisely because such standards are not easy to set, and different reviewers will produce different judgments. Therefore, the definition of "good design" has always been the most interesting and philosophical dialectical field in the design profession.

2.2. Purpose of the Design Awards and Mechanism for Participation

When talking about "Good Design", the design award has to be mentioned. Although each design award has a different purpose, the attempt to define, praise, encourage, and even influence how the society sees "Good Design" are the common purposes for most of them.

The design awards have gradually taken shape since the 1950s. In order to help the public distinguish high-quality designs and encourage the production of them, the form of certification and encouragement are given.

Design awards are usually run by specific organizations and employ judges to decide which works meet their criteria for awards and to place a ranking. Through the awards and the interpretation of the judges, the public will more easily understand the value of design. The design award gives design practitioners a quantifiable metric as proof of differentiation from other design peers. Through promotion, the winning works have a higher exposure. Design awards offer occasions for business matching. Through the award criteria and feedback, designers can improve their design skills. In addition, through the publicity of the awards, the original status of the winning works has also been established.

Design awards are often established to convey certain design values. In particular, awards that focus on special fields will help increase the public's attention to issues in this field (such as environmental protection, sustainability, and technology). Design awards can also be used as incentives to give designers more motivation to make designs better. Design awards also directly or indirectly provide designers with financial benefits (ex. bonuses or government incentives) [11].

A' has a similar explanation for the purpose of its award: the purpose of a good design competition (or award) is to discover and promote good designs so that good designers can have more public exposure and access to more, updated audiences, potential customers, design enthusiasts, and media. Good designers could create more good designs, obtain more funding, and form a positive cycle. In addition, participating in the award can also positively enhance the designer's sociability, popularity, and vision expansion [12].

G-Mark proposes: The purpose of the establishment of the design award is to explore and commend good design through design awards and to enrich our life and society [13].

To sum up, the three main impacts of the design award are: (1) raise public awareness of good design, (2) provide incentives for designers and brands to create better designs, and (3) establish and support good design and bring good taste, cultural influence, to achieve educational purposes [11].

Today, the categories of design awards are increasing day by day. There are some awards that set the theme according to the design field (such as: green design, service design, interactive design, etc.), and some are established to shape the social image of the organizer or the demand for design (such as: Lexus Design Award). The categories and goals of these design awards are becoming more and more diverse, and the demands and target groups are gradually becoming more niche. The "Design Award Phenomenon" discussed here belongs to the more mainstream and common category.

According to the different ways of participation, the design awards can be roughly divided into two types: "Registration System" and "Nomination System". The "Registration System" provides an application channel, allowing those who wish to participate to sign

up on their own. This type of design award is represented by the awards discussed in the "Design Award Phenomenon": iF, Reddot, G-Mark and A', etc.

The "Nomination System" design award usually excludes the channel of self-registration. The organizer invites experts or committees to provide participating designs by nomination. This type of design award usually considers fairness and will require nominators not to nominate designs that they participated in. This type of design award is represented by the Design of the Year Award (hereinafter referred to as "BDOTY") and the Pritzker Architecture Prize (hereinafter referred to as "Pritzker").

There are also some special hybrid forms, such as "The greatest designs of modern times" launched by Fortune Magazine, which invites top designers, scholars, etc. to list up to 10 best designs each and provide reasons for nomination. Then, according to the number of nominations, the top ranking is determined. For those who have been nominated less often and cannot reach a majority consensus, researchers will use language analysis to determine the remaining rankings using five evaluation criteria: "how adaptable and expandable the product is"; "impact on society or the environment"; "ease of use"; "commercial success"; and "whether it redefined its category" [14].

Through data collection, expert consensus meetings, etc., this study sorted out the differences, advantages, and disadvantages of the two categories of design awards: the registration system and the nomination system.

The list is as follows in Table 1.

Table 1. Mechanism for participating in design awards.

Participation Mechanism	Registration System	Nomination System
Participation conditions	Participants must register by themselves. Usually, the organizer will set up basic conditions (such as: application qualifications, registration process, whether to charge or not, etc.). Applicants are only eligible to participate after submitting application materials, fees (if any), design, etc.	The committee members approved by the design award organizers will nominate designs according to criteria and conditions, and only those who have been nominated could participate. Usually, the conditions that nominators cannot nominate works they involved, and there is no direct interest between the nominators and the nominees.
Participant(s)	It is usually registered by design units (such as designers, design companies, design students, design schools, etc.) or production, distribution, and marketing units (such as brand owners, manufacturers, etc.).	Unless special conditions are set, all designers and their works are eligible for nomination.
Operation	There are usually two types: paid and free. Registration fees are usually used directly to maintain the running costs of the organizer. Those who provide free registration usually want to increase the number of entries, and usually have funds to support operations (such as government or consortium funding)	Most of the participation in this type of design award is free, and the organizer usually has indirect funds to support the operation (such as: government or consortium funding)
Motivation(s) to Participate	1. Public recognition 2. Increase design prestige and visibility 3. Direct profit (bonus) or indirect funding (government or consortium subsidy) 4. Marketing purpose 5. Business Matching Opportunities	Nominator(s): 1. Hope that good designers/works can be recognized 2. When the nominated works are shortlisted and win, it proves good taste and vision of the nominator. 3. The sense of honor when the nominated works are shortlisted and awarded 4. Maintain relationships with award organizers and the design community
Advantage(s)	An unknown participant may become famous after being awarded.	All designs that meet the award criteria can be selected, regardless of the designer/company's willingness to participate.
Disadvantage(s)	Some international awards require high registration fees and complicated registration procedures. Designers and design companies who already have international reputation, or do not want to pay the registration fee or handle the registration process, are less willing to participate. Without the above-mentioned participants, the representative of the design award is limited.	Designers/works with low reputation and visibility are less likely to be nominated because the nominators may not even know their existence.

Source: this study.

The "Design Award Phenomenon" mentioned in this study includes iF, Reddot, and A', all of which belong to the "Registration System". The design awards of the "Nomination System" include Pritzker, BDOTY, etc. Due to fundamental differences in motivation and methods of participation, the latter are not within the scope of this study. Follow-up researchers can further explore related issues.

2.3. The Impact of Design Awards on Academics and Business

The value of design in business has been widely recognized by the market and customers as a way to enhance corporate profits and brand prestige [15]. However, what about design awards? Scholars have found that most respondents believe that the winning works of design awards may not bring direct economic profits to enterprises, but they should have indirect profits. However, the same study also pointed out that the impact of design awards on enterprise performance, whether it is direct or indirect profit, is not significant. In other words, the indirect profit brought by the design award is not as good as expected [16].

Some studies have also shown that award-winning designs are not usually the best-selling items. The study also raises a dilemma: should designers continue to pursue the design standards set by the design awards or put more thought into creating business value for their clients [17]? There seems to be a gap between the ideal standards revealed by the design awards and the reality of the commercial market.

The same dilemma also appears in design education. When the number of design awards is the main evaluation target of school evaluation, it will inevitably crowd out other values that should be taught in design education. After graduation, students face the challenges of the real world, which can no longer be solved simply by winning awards. Designers are entering a new era of "Society 5.0", with its complex and heavy challenges [18]. Whether a designer can adapt to the rapid changes in the complex environment, as well as the challenges from business and execution, are the real keys to survival.

Don Norman, a well known design scholar, has questioned the current design education and proposed reform. He believes that the current design education is too focused on technical or aesthetic disciplines, and lacks the basic understanding of interdisciplinary (e.g., sociology, science, statistics, etc.) cultivation. The solutions proposed by designers are often superficial or overly simplified due to the lack of knowledge in other fields. Since much design education is conducted in this context, it is difficult for faculty or design award judges to break out of this framework. As a result, even though there are many designers who can produce good-looking and even award-winning designs, they are not able to propose solutions that truly address the core of the problem in the complex real world [19].

Too much attention to design awards may result in similarity in style and form or limitations in thinking. Academic studies have used AI to examine and analyze the appearance of award-winning designs. Using this system, the likelihood of an entry winning an award becomes predictable [20]. There are also books by experienced award-winning designers that teach the secrets of winning awards [21]. When most designers pursue the same design award criteria, or when the results of design awards can be deciphered by appearance or formulaic methods, it is easy for designers to become homogenized and lack the will to think, reflect, break through, or even challenge authority. As a result, in the face of more brutal and complex challenges, designers' vision and ability may not be macroscopic enough to deal with them.

2.4. Design Rankings by Schools, Cities, and Countries

For 'Good Design', it seems that design scholars and experts can't be satisfied with the formulation or debates of definitions, or the giving and praise of awards. How should one distinguish between 'Good Design'? How does one find 'Better Design' or 'Best Design' among the many good designs? The design ranking mechanism was born in response, and it has become an important basis for the design community to compare, evaluate, or improve.

Among various design rankings, there are rankings for different subjects, such as people, companies, schools, cities, and countries. This study attempts to challenge the

current method of assessing the national design level by the number of design awards and to identify a more appropriate framework. Therefore, the design evaluation mechanism for collective units is the focus of this study, and the ones for individuals, companies, etc. will not be discussed here.

2.4.1. Design School Rankings

With the trend of globalization and marketization, competition among academic institutions has become increasingly intense, and school rankings are a product of this context [22]. A good ranking is not only a condition to attract excellent students and teachers, but also an important basis for the public to examine the management quality of academic institutions [23]. Ranking is a very convenient reference for school enrollment, students' choice of schools, evaluation by competent authorities or resource allocation.

The ranking of design schools can be roughly classified into two categories: "Design Award System" and "Comprehensive Evaluation System". The "Design Award System" is represented by the Reddot Design Ranking (hereinafter referred to as RDR), established by Reddot, and is ranked according to the number of Reddot Design Concept awards obtained by the evaluated units in the past five years [24].

The "Comprehensive Evaluation System" is represented by "The QS World University Rankings by Subject: Art & Design (hereinafter referred to as QS)". Representatives of various schools and enterprises participate in the evaluation and list the best design schools in their minds (up to 10 domestic and 30 international institutions per response). In addition, the impact of research papers is also listed as a benchmark for evaluation. "Academic Reputation", "Employer Reputation", and "Research Impact" become the three criteria used to comprehensively evaluate the level of design schools [25].

The latest rankings of design schools for both systems are as follows in Table 2:

Table 2. Design School Rankings.

	Reddot Design Ranking, 2022	**The QS World University Rankings by Subject: Art & Design 2022**
Participation	Registration System	Nomination System
Criteria	# of Design Awards	Academic Reputation, Employer Reputation, Research Impact
Top Ranking Schools	Universities (Americas and Europe) 1. Umeå Institute of Design, Sweden 2. Savannah College of Art and Design, USA 3. University of Montreal, School of Design, GRAD Research Lab, Canada 4. Royal College of Art (RCA), UK 5. Delft University of Technology, Netherlands Universities (Asia Pacific) (Reddot Design Ranking, 2022) 1. National Taiwan University of Science and Technology (Taiwan Tech), Taiwan, R.O.C. 2. Dalian Minzu University, China 3. Massey University, New Zealand 4. Hongik University, South Korea 5. Guangzhou Academy of Fine Arts, China	1. Royal College of Art, UK 2. University of the Arts London, UK 3. The New School, New York, USA 4. Rhode Island School of Design (RISD), USA 5. Politecnico di Milano, Italy 6. Aalto University, Finland 7. Pratt Institute, USA 8. Massachusetts Institute of Technology, USA 9. Design Academy Eindhoven, Netherlands 10. School of the Art Institute of Chicago, USA

Source: organized by this study [24,26].

Comparing the school rankings made by the "Design Award System" and the "Comprehensive Evaluation System", several interesting phenomena could be found: (1) the "Design Award System" only uses the number of single design award as the evaluation criteria for the evaluation unit (school), while the "Comprehensive Evaluation System" usually refers to more evaluation indicators and asks a certain number of experts to take the assessment. (2) Except for the Royal College of Art, London (UK), the two top-ranked

lists do not overlap at all. (3) Reddot Design Ranking does not compare schools from all over the world, but distinguishes the two major regions of "Asia Pacific" and "Americas & Europe", and then compares and ranks them separately. 4). The Asian schools in the Reddot Design Ranking are not at the top of the QS rankings [24,26].

From the above inference, there will be a considerable difference between using the number of design awards and using the comprehensive evaluation index as the benchmark for ranking design schools. The latter combines the views of experts from both academia and industry and can represent a larger consensus in the design community. Therefore, this result can also be interpreted as: when the number of design awards is used as the evaluation benchmark for design schools, the results obtained will be quite different from the consensus of the design community.

Will there be similar conclusions when the unit of assessment is changed from school to country?

2.4.2. Design Cities Ranking

Among the design evaluation mechanisms based on cities, the more well-known and influential ones include World Design Capital® (hereinafter referred to as WDC), UNESCO City of Design (hereinafter referred to as UCD), and The Top 10 Design Cities (hereinafter referred to as T10).

WDC is organized by the World Design Organization® (WDO), and every two years a city is elected for the WDC title. Cities interested in WDC must register with the organizer and prove that the city effectively uses design in economic, social, cultural, environmental, and other aspects of development. Once selected, the city is required to host a year-long event related to sustainable design, urban policy, and innovation [27].

UCD is a part of the UNESCO Creative Cities Network, which includes "Literature", "Design", "Crafts and Folk Art", "Film", "Music", "Media Arts", and "Gastronomy". The purpose of UCD is to promote the design value of cities and to use design to improve urban life and solve urban problems. The selected cities communicate, observe, learn, and stimulate growth with each other [28].

If a city wants to be selected for the WDC or UCD, it must submit the relevant application documents and pay the registration fee, and the final winner will be selected through the review process. This is similar to the "Registration System" design awards mentioned above: only those who have registered have the opportunity to be evaluated. Therefore, if a city is selected for WDC or UCD, it only means that the city meets the standards required by WDC or UCD, or puts forward more competitive conditions than competing cities.

After examining the relevant goals and evaluation criteria, it can be found that WDC and UCD focus more on the use of design in urban planning, policy formulation, and international activity. In other words, WDC and UCD pay more attention to the city's enthusiasm for design investment, rather than directly reflecting the city's overall design level.

Comparing the list of WDC and UCD, it will be found that almost all cities that obtained WDC are also selected for UCD, except that Taipei, which does not have the membership of UNESCO. Also, cities with a long-term boom in design are still missing from both lists (London, New York, Tokyo, Paris, etc.).

Based on the above discussion, the following arguments can be drawn: (1) most of the cities selected for WDC or UCD are actively using design in urban development, or participating in relevant international organizations; (2) cities that have not registered or obtained the title of WDC/UCD cannot be said to be inferior to the selected cities in terms of design and creativity; (3) WDC or UCD are more suitable for examining the design application status of a city and whether it actively participates in international design organization. It is not suitable for comparing the overall design level between cities.

Organized by Metropolis Magazine, T10 annually selects the 10 best design cities in the world. According to the official website, T10 was assessed using an "unusual approach"

in 2018 (Metropolis Magazine, 2018). Although it is not clear how the "usual approach" does it, the so-called "unusual approach" is still quite worthwhile to refer to.

Metropolis Magazine obtained responses from 80 of the world's top designers and architects, who nominated their best match in 3 categories—"design powerhouses", "buzzing cultural hubs", and "cities that inspire or personally resonate with them". The T10 list selected by this model includes cities such as Milan, London, Berlin, which are famous for their design and meet the expectations of design experts, as well as cities such as Shanghai, which are full of new vitality and cultural integration [29].

T10 has set a reasonable evaluation benchmark and obtained feedback from a certain number of design experts. The result is not too surprising or unpredictable, which can be said to be in line with the consensus of design professionals. However, what is interesting is that the new list launched by T10 in 2019 does not seem to adopt the same evaluation criteria and consensus of external experts as in 2018. The selected list of cities is quite different from that in 2018.

List of Design Cities in WDC, UCD, and T10 could be seen in Table 3.

Table 3. List of Design Cities in WDC, UCD, and T10.

	World Design Capital (WDC)	**UNESCO City of Design (UCD)**	**The Top 10 Design Cities (T10)**
Participation	Registration System	Registration System	Nomination System
Selected Cities	Torino (Italy, 2008), Seoul (South Korea, 2010), Helsinki (Finland, 2o12), Cape Town (South Africa, 2014), Taipei (Taiwan, 2016), Mexico City (Mexico, 2018), Lille Metropole (France, 2o2o), Valencia (Spain, 2022)	Bandung, Bangkok, Beijing, Cape Town, Detroit, Graz, Montreal, Wuhan, Mexico City, Nagoya, Helsinki, Istanbul, Seoul, Torino, etc. This totals around 40 cities.	T10, 2018 Milan, London, Berlin, Shanghai, etc. T10, 2019 Lima, Peru · Buenos Aires, Argentina · Tirana, Albania · Valencia, Spain · Tulsa, Oklahoma · Memphis.

Source: organized by this study [27–30].

To conclude, the WDC/UCD evaluation mechanisms are based on a registration system in which only the cities that applied could be evaluated. The real significance of being selected is that, among the cities that registered, these cities demonstrate a higher degree of compliance with the evaluation criteria or preferences of the judges.

In contrast, the T10 adopts the nomination system, which does not consider the willingness of cities to apply for participation. As a result, cities around the world are automatically included in the evaluation, which is a better way to examine the overall design level of cities around the world. In addition, since a certain number of design experts participated in the assessment, the results are more in line with the expectations of design professionals.

2.4.3. Design Rankings for Countries

When the scope of the assessment is extended to countries or regions, the relevant measurement mechanisms are rather scarce. Most of the recently found and still active ones are related to design awards, namely, "iF Ranking (hereinafter referred to as iF-R)" issued by iF, and "World Design Ranking (hereinafter referred to as WDR)", published by A'. Looking further back in time, we found the "Design Competitiveness Ranking" (hereinafter referred to as DCR) published by DESIGNIUM-Center for Innovation Design.

iF-R is ranked according to the number of iF Design Awards a unit has won, according to its official website: "Which companies, countries or creatives have won the most iF DESIGN AWARDS? Filter by continent, country or industry". It seems that the system can perform ranking queries with categories, such as continent, country, or industry. However, in practice, "Country" cannot be used as a ranking category. According to iF employees, this is to avoid unnecessary misunderstandings and comparisons [31].

The WDR is one of the very few country-based design rankings. Rankings are compared according to the number of As a country has received, and the number of the highest

level of awards (Platinum Design Award) determines the ranking priority. In the event of a tie, items such as the next level of awards and total points will be included in the comparison. Different levels of awards are given different points, from the lowest "Iron Design Award" (+2 points) to the highest "Platinum Design Award" (+6 points).

In the 2022 WDR ranking, China ranks first in the world (1/102/11259), and Hong Kong (5/23/3030) and Taiwan (7/17/6052) are also in the top ten. Chinese design occupies three places in the Top 10 list! Other notable countries include: Turkey (8/15/1917), Netherlands (14/10/356), Switzerland (16/8/297), India (20/5/1043), Singapore (21/5/689), Finland (24/4/186), France (28/3/407), Denmark (61/0/157), etc. The numbers marked after the above countries/regions represent the country/region's overall ranking in the WDR/the number of "Platinum Design Award" awards/ the total WDR score [3] (see Table 4).

Table 4. Top 28 countries/regions in WDR, 2022.

Rank	Country/Area	Number of Platinum Design Awards	Score
1.	China	110	13,741
2.	USA	74	4693
3.	Japan	48	2574
4.	Italy	36	2122
5.	Hong Kong, China	27	3240
6.	UK	20	1301
7.	Taiwan	17	6896
8.	Turkey	15	2012
9.	Germany	15	1198
10.	Portugal	12	637
11.	Australia	12	558
12.	Brazil	11	1190
13.	Spain	10	733
14.	Netherlands	10	391
15.	Poland	8	456
16.	Switzerland	8	323
17.	Republic of Korea	7	972
18.	Canada	6	759
19.	Russian Feration	5	973
20.	India	5	1043
21.	Singapore	5	755
22.	Hungary	5	380
23.	France	4	429
24.	Ukraine	4	304
25.	Finland	4	205
26.	Norway	4	112
27.	Lithuania	3	367
28.	Mexico	3	419

Source: organized by this study [3].

The DCR is supported by the European Union and was published in the World Economic Forum in 2002, 2005 and 2007. The ranking has seven indicators, focusing on the resources invested by enterprises in R&D—"Company Spending on R&D", the positioning of enterprises in the global market—"Nature of Competitive Advantage", the positioning of enterprise on value chain—"Value Chain Breadth", how companies adopt its innovative approach—"Capacity for Innovation", the status of technology used in product manufacturing—"Production Process Sophistication", the diversity of marketing strategies—"Extent of Marketing" and the service quality to customers—and "Degree of Customer Orientation". According to the above-mentioned indicators, representatives of different countries evaluate their own countries [32].

DCR clearly has a more diverse and rigorous view than WDR. However, the most recent DCRs available for this study are more than ten years old and may not be able to keep up with the changes in the design field over the years. In addition, the evaluation criteria

used in the DCRs seem to be more oriented toward product design and lack comprehensive representation of other design categories, especially new forms of design that have been developed in this decade (e.g., service design, digital design, XR design, etc.). In addition, the evaluation criteria place a lot of emphasis on the attitude and approach to innovation and technology adopted by companies in each country. The above indicators seem to be more related to national economic competitiveness, and the relevance of the national design level needs to be further examined. Spain, Italy and other countries that are recognized as having very high design standards, if they do not invest as much in science and technology, their ranking may not be as advantageous under such criteria.

The top ranking list of WDR and DCR could be seen in Table 5.

Table 5. Design Countries Rankings.

	World Design Ranking (WDR), 2022	**Design Competitiveness Ranking (DCR), 2007**
Participation	Registration System	No need to register
Criteria	# of Design Awards	1. Company spending on R&D 2. Nature of competitive advantage 3. Value chain breadth 4. Capacity for Innovation 5. Production process sophistication 6. Extent of marketing 7. Degree of customer orientation
Top Ranking Countries	1. China 2. USA 3. Japan 4. Italy 5. Hong Kong (China) 6. UK 7. Taiwan 8. Turkey 9. Germany 10. Portugal	1. Germany 2. Switzerland 3. Japan 4. Sweden 5. Denmark 6. Austria 7. USA 8. Finland 9. South Korea 10. France

Source: organized by this study [3,32].

Can WDR or DCR represent the design level of each country? According to the latest results of the two rankings, there seems to be a considerable degree of difference. WDR only takes the number of design awards as the evaluation index, which has the common defect of the registration system: it is difficult to make a comprehensive comparison among countries with different participation motivations and conditions. On the other hand, DCR has the above-mentioned defects, so it may not be so suitable as the object of verification. In the absence of other rankings or academic discussions, this study chose to re-construct the evaluation framework and invited design experts to use the new benchmark for evaluation. Through a more rigorous, diverse and contemporary viewpoint, this study hopes to dig out some insights.

3. Research Design

This study explored two issues: (1) sould the number of design awards represent the design level of a country? (2) If the design award is not suitable as an evaluation benchmark, is there a more appropriate one?

At present, it is known that WDR uses the number of design awards as the benchmark for ranking the design level among countries. However, how should one verify that the result is appropriate? Determining whether the method is reasonable is difficult due to the lack of other measurement frameworks. Therefore, the focus of this study is to find out how design professionals identify the benchmark of national design level and what key factors affect their perception. The new standard derived from the above content is used to

evaluate the global design level, and the results are compared with the previously obtained rankings to find possible contexts.

The research steps are divided into the following stages: (1) literature research and interview stage, (2) structure, methods, and criteria induction, (3) pre-test stage, (4) formal questionnaire stage, and (5) statistics and analysis stage (see Figure 1).

Figure 1. Research process.

In general, when designing indicators or assessment criteria for evaluation, the scope of the target population or the ease of obtaining assessment data are considered. In the case of global university rankings, it is difficult to obtain information or data from universities around the world, or to verify the accuracy of the data, so the design of other evaluation criteria should be considered. For example, QS has chosen to use university reputation as a measurement criterion and formed the characteristics of the ranking [33].

It is the same when assessing the design level of each country, as there may be situations in which objective data is needed, such as the "employment status of designers" and "the operation status of design companies" in various countries. Considering the difficulty of collecting data from multiple countries and the huge workload, we can only settle for the next best thing. The qualitative "impression score" is used as the subject of evaluation.

3.1. Literature Review and Expert Interview

In the absence of a comparison mechanism, in order to verify whether WDR's evaluation framework is reasonable, this study is based on the spirit of "Grounded Theory" and tries to construct a new framework as a comparison. According to the collected empirical data, a theory close to the essence is obtained through systematic analysis. The research adopts four common methods of "Grounded Theory": "inductive data", "iterative method", "interactive method", and "comparative method" [34].

Starting from the literature review and expert interviews, the research tries to find out the key factors that will affect the experts' evaluation of the design level of each country. First, the design evaluation mechanism for different units (such as cities, schools) was reviewed, trying to find elements worth referring to when evaluating countries.

In the process of the literature review, we mainly compare and analyze the existing design evaluation mechanisms, trying to find out the advantages (pros) and disadvantages (cons) of different mechanisms, and clarify the rationality of various architectures. Through expert consensus meetings, evaluation frameworks were selected, for their results are more in line with the expert perception. Next, the common characteristics of these frameworks are sorted out, and an evaluation framework and method suitable for this study are constructed.

In order to establish an evaluation framework that accords with the cognition of design experts, interviews with relevant experts are very helpful. The expert interview process adopts open-ended question, trying to find out from what angle(s) a design expert will approach when evaluating a country's design level. What are the key factors that will influence the expert's judgment? Examples of interview topics are: (1) how do you evaluate the design level of a country? (2) When someone mentions whether a country's design level is high or low, what do you think is the key factor that makes the difference? (3) Countries are often evaluated and ranked by economic strength, military strength, etc. If there is a national "design strength" evaluation, how should it be evaluated?

3.2. Structure, Methods, and Criteria Induction

During the literature review phase, it was found that all design rankings (e.g., RDR, WDC, UCD, WDR) that use the registration system have the drawback that non-registered

units cannot be evaluated. After the expert consensus meeting, it was concluded that such rankings could not be used comprehensively to examine the design levels of schools, cities, or countries around the world and were not suitable as a model for this study.

QS/T10 utilizes a variety of evaluation criteria with the participation of a certain number of experts. The results are more in line with the experts' perceptions. However, we also found that QS/T10 could not include all the evaluated units (schools, cities) in the ranking. QS/T10 invites experts to list a certain number of the best design schools and cities that meet the evaluation criteria and then ranks them cumulatively. This method is very helpful to find out the best design schools and cities that most experts agree on, but it is not easy to rank the middle and fall-behind groups. In order to fill the gap, it may be necessary to rely on other objective data. Since the acquisition of global objective data requires a lot of manpower, time, and money, it may be necessary to wait until future research conditions permit. Therefore, this study is based on the QS/T10 rating framework, with some minor modifications. Instead of just giving a list of the best in mind, the experts rate each country according to the assessment criteria. In this way, the units in the middle and fall-behind design categories can be evaluated as well.

In terms of expert interviews, the invited interviewees are mainly design experts who have a good understanding of the international design status. The key points of the interviews will be excerpted and reviewed, screened, refined, and summarized through expert consensus meetings. The criteria for later evaluations are derived from this. In addition, the expert consensus meeting also identified the countries and design fields to be assessed.

Steps to establish an evaluation framework could be seen in Figure 2.

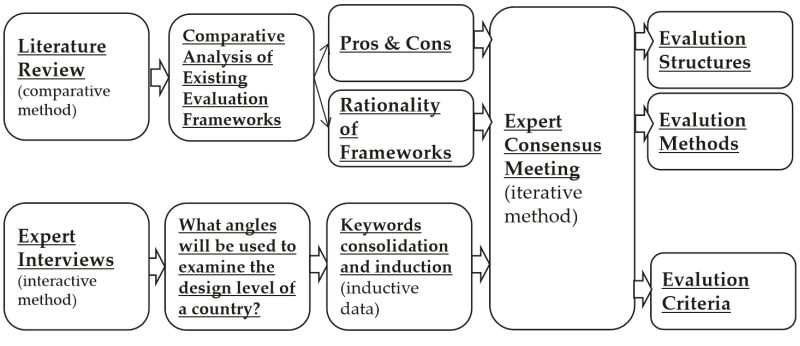

Figure 2. Steps to establish an evaluation framework, based on the four common methods of "Grounded Theory": "inductive data", "iterative method", "interactive method", and "comparative method".

According to the results of the interviews, it is found that when design experts assess the design level of a country, the perspectives they take can be roughly classified into the following five indicators: "International Activity Index", "International Learning Index", "Top Design Index", "Daily Design Index", and "Cross-border Business Index". The above indicators can be further divided into two categories of "People" and "Things", and a total of 10 evaluation criteria are obtained (see Table 6).

Table 6. Criteria derived from the first stage induction.

	People	Things
International Activity Index	How visible are the country's designers in the international media?	Do the country's design works often attract international attention and lead the conversation?
International Learning Index	Are designers in the country targeted for international learning and imitation?	Are the country's design works the target of international study?

Table 6. *Cont.*

	People	Things
Top Design Index	Does the country have many internationally renowned design masters, design stars, design companies, and high-profile design rookies?	Are the country's design works often included in the permanent collections of international design museums? Are these pieces internationally recognized as classic, timeless designs?
Daily Design Index	Do the people in the country have good design taste for commonly used or purchased items?	Is there a high level of environmental design in everyday life in the country? (Public construction, buildings, transportation, etc.)
Cross-border Business Index	Are designers in this country often invited by other countries to conduct design projects commissioned by governments, enterprises, brands, etc.?	Are designs in this country often the subject of purchases from other countries?

Source: this study.

3.3. Pre-Test

With reference to the WDR, five countries/regions for evaluation were selected through an expert consensus meeting, including: Taiwan (7/17/6052), Turkey (8/15/1917), India (20/5/1043), France (28/3/407), and Denmark (61/0/157). The numbers marked after the above countries/regions represent the country/region's annual overall ranking in WDR/the number of "Platinum Design Award" won/the total WDR score.

The selection of these countries is based on two conditions: (1) the countries/regions with the leading, mid-level and fall-behind design levels recognized by the experts must be included; (2) those with a gap between the WDR ranking and the actual design level perceived by experts are preferred to be selected.

Based on the summarized assessment criteria, a questionnaire was designed and distributed. Then, after preliminary statistical analysis of the results, the evaluation criteria were further re-examined. Factors with low reliability/validity or overlapping effects were removed. Afterwards, the next stage of questionnaire and analysis was carried out using the restructured evaluation criteria.

3.4. Formal Questionnaire

After the questionnaire and statistical results obtained in the pre-test stage, as well as the feedback from the respondents, this study further consolidated the relevant benchmarks. Three major indicators and six evaluation criteria are formed, as shown in Table 7.

Table 7. Three major indicators and six evaluation criteria used to evaluate the national design level.

Index	Criteria
Designer Index	1. How active are a country's designers internationally. (International Activity)
	2. The overall designers' level in a country. (Designers Level)
Zeitgeist Index	3. The ability of a country's design to reveal and lead future trends. (Future Trends)
	4. The influence of the country's designs on world design history. (Historical Impact)
Living Index	5. The design taste of the objects that people in the country use or buy on a daily basis. (Lifestyle Taste)
	6. Design level of the country's environment (public constructions, buildings, vehicles, etc.). (Environment Standards)

Source: this study.

The questionnaire is divided into three parts: basic information, questionnaire introduction, and evaluation content. The basic information is mainly to obtain the profiles of the respondents, such as gender, age, education level, design professional qualifications, etc. For the content of the evaluation, the respondents are asked to rate each country according to the six "Criteria". There is also a comprehensive design evaluation for each country, "Overall Impression", which is used for comparison and reference purposes. In this questionnaire, a 7-point Likert scale is used. The results of the questionnaire will also be used for comparison and analysis with WDR.

Since the discussion of related topics requires a considerable understanding of the design status of various countries, the respondents are mainly design experts who have long-term observations on the international design status or have considerable experience in international design activities.

After discussion at the expert consensus meeting, nine countries/regions were selected for evaluation, including: South Korea (17/7/972), the USA (2/74/4690), India (20/5/1043), Denmark (61/ 0/157), Taiwan (7/17/6052), France (28/3/407), Japan (3/48/2574), South Africa (32/3/118), and Turkey (8/15/1917). The numbers marked after the above countries/regions represent the country/region's annual overall ranking in WDR/the number of "Platinum Design Award" won/the total WDR score.

To select the countries/regions to be evaluated at this stage, the expert consensus meeting first refers to the WDR list and selects two to four countries that the experts consider to be in the leading, middle, and fall-behind stages of the international design level. In addition to countries such as Japan and the United States that have little difference between the WDR ranking and expert cognition, countries with large differences in WDR ranking and expert cognition (such as Denmark, France, India, etc.) are also selected as comparisons. It is hoped that through follow-up questionnaires and statistical analysis, the correlation between evaluation criteria and national rankings will be found.

3.5. Statistics and Analysis

In order to explore the comparison of design strengths among countries/regions, and to find out the correlation between each criterion and the overall evaluation, this study uses methods such as MDS (multidimensional scaling), ANOVA, and regression analysis to interpret the data.

The questionnaire was carried out in two stages. In the first stage, a total of 76 questionnaires were collected; in the second stage, a total of 106 questionnaires were collected. The proportion of male and female respondents in the second stage was nearly half (50.9% and 49.1%); the age groups were mainly 40–60 years old (58.5%) and 20–40 years old (30.2%); the highest educational background was graduate school (68.9%/ 25.5%) and universities (25.5%); for design professional experience, seniors are the main ones (64.2%), followed by three to six years of experience (12.3%).

4. Findings and Discussions

4.1. Descriptive Statistics

The questions are divided into two parts. The first part evaluates the overall design level (overall impression) of nine countries/regions. In the second part, respondents are asked to rate the design status of each country/region based on the six criteria summarized in this study. The average score of "Overall Impression" obtained by each country/region in descending order is: Japan (6.27), France (6.13), Denmark (6.12), USA (6.04), South Korea (5.25), Taiwan (4.80), Turkey (4.05), South Africa (3.96), and India (3.80).

The scores for the six criteria show different results across countries/regions, but generally still echo the "Overall Impression" scores, with differences between individual criterion(s). Countries with high "Overall Impression" scores generally also perform well across individual criterion, but those with the highest "Overall Impression" scores may not necessarily have the highest individual criterion. Compared with other countries in the top scorer group, the scores in different criteria are different; a similar situation can be seen in the middle or fall-behind countries (see Table 8).

Table 8. The scores and statistical pressure coefficients obtained by each country/region in the overall (f0—"Overall Impression") and individual (f1~f6) criteria.

f1 International Activity	5.16	6.30	3.77	5.96	4.51	6.15	6.22	3.79	3.92
f2 Designers Level	5.11	5.88	3.66	6.07	4.79	5.96	6.18	3.78	3.88
f3 Future Trends	5.08	6.13	3.64	5.92	4.36	5.87	6.08	3.64	3.68
f4 Historical Impact	4.39	6.05	3.49	5.83	3.88	6	5.92	3.3	3.63
f5 Life Style Taste	4.93	4.99	3.05	6.18	4.35	6.15	6.2	3.58	3.75
f6 Environment Standard	5.15	5.31	2.77	6.18	4.39	5.76	6.32	3.67	3.71
f0 Overall Impression	5.25	6.04	3.8	6.12	4.8	6.13	6.27	3.96	4.05

Source: this study.

4.2. MDS (Multidimensional Scaling) Analysis

From the descriptive statistics, it can be roughly seen that there is a certain degree of correlation between the "Overall Impression" scores given by design experts for each country/region and the individual criterion scores. But how does one interpret this correlation? What are the strengths and weaknesses of each country? How does each criterion affect the difference in overall score distribution? These questions are difficult to draw intuitively from descriptive statistics. Therefore, this study adopts the MDS analysis method to further analyze the results of the questionnaires.

Through MDS analysis, the measured units have different landing positions in space, and with the axis coordinates formed by each evaluation criterion, it is possible to delineate the subgroups among the units and find out the similarities and differences between them.

Another important information is OD distance in a MDS plot. On the coordinate plane, each point of the observed countries has an orthogonal projection on the vectors (representing each evaluation criterion). The distance of projection point D onto the origin point O demonstrates the characteristic strength, of which the vector contributes to the country (see Figure 3).

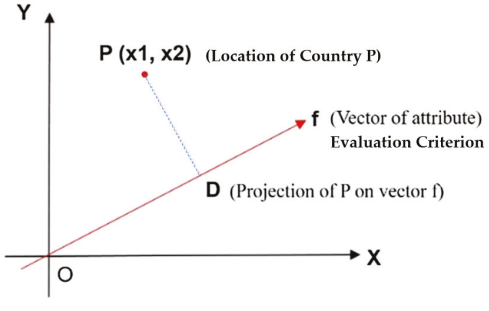

Figure 3. OD distance on MDS plot.

Also, we found out that two criteria, "f1-International Activity" and "f5-Life Style Taste", are about 90 degree in space. If we take these two as new axes and draw new coordinate geometry, four new quadrants would be formed (see Figure 4, Table 9).

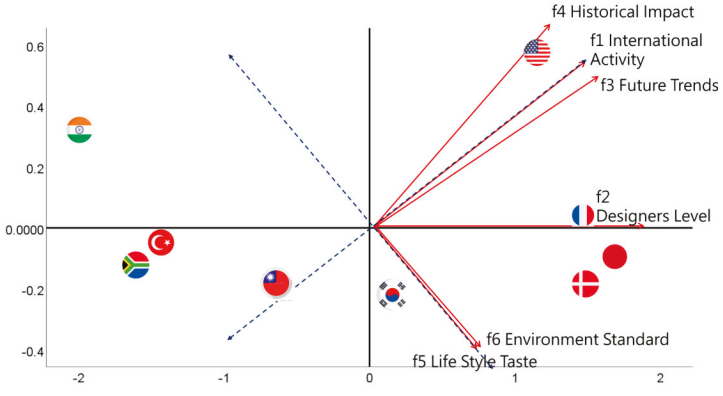

Figure 4. MDS chart.

Table 9. Stress and squared correlation (RSQ) in distances & Configuration derived in 2 dimensions. For matrix. Stress =0.01158 RSQ = 0.99976. Stimulus Coordinates Dimension.

Stimulus Num-ber	Stimulus Name	1	2
1	k	0.0928	−0.2359
2	a	1.1335	0.5690
3	i	−1.9621	0.3218
4	d	1.4764	−0.1739
5	r	−0.6801	−0.1854
6	f	1.4257	0.0318
7	j	1.6408	−0.1248
8	s	−1.6502	−0.1304
9	t	−1.4766	−0.0723

Source: this study.

Through this new coordinate geometry, it can be seen that the landing points of the nine countries/regions can be roughly divided into the following groups:

- Leading Countries

All countries that fall into the new 2nd quadrant, France, Japan, and Denmark, are the leading design countries that score high in all attributes. On the other hand, the United States, despite falling into the new 1st quadrant due to mediocre performance in "Environment Standard" and "Life Style Taste", still has impressively high scores in other categories, and thus is still a leader in design. All the above countries correspond to their high "overall impression" scores (from USA's 6.04 to Japan's 6.27), thus they could be proven to be the leading countries in design.

Among the design-leading groups, France, Japan, and Denmark are quite close in the MDS chart, and they all scored high in each criterion.

Japan: except for "Historical Impact", which is slightly inferior to the United States and France, all other criteria ranked 1st or 2nd, which can be said to be the most comprehensive design leading country this time. The position in MDS also echoes the highest score achieved by "Overall Impression".

France and Denmark: The two countries are very close to Japan in the MDS chart. When looking at the vertical position of each criterion axis, they can obtain quite high-level landing points, and the results also echo the statistical data. Denmark has many world-class design masters and classic and timeless design works. In addition, high-quality design can be seen almost everywhere in Denmark, and "Good Design" is integrated into the daily life and environment of ordinary citizens. These are all reasons why Denmark is a design leader. France has many influential international design celebrities, creative and surprising design works, as well as high-profile design rookies, the ability to lead future design trends, and

people's attention to life taste. These are the key strengths of French design at the forefront. Denmark and France were highly appraised by all critics, and "Overall Impression" closely followed Japan with only a slight gap, which proved the impression of the two countries as design powerhouses in the eyes of experts.

USA: The USA is the only country in the leading group that falls in the new 1st quadrant (but, on the edge of the second quadrant). American designers are often invited by other countries to carry out design projects, speeches, teaching and other activities. Many American designs also play a pivotal role in design history, becoming "Iconic Designs". In addition, futuristic design innovations often sprout from the USA. The above situation can be proved in the MDS chart: the USA is in the highest position on the axes of "International Activity", "Historical Impact", and "Future Trends". It could also be seen in the descriptive statistics that the USA has the highest score among the nine countries/regions in these corresponding criteria.

How can the USA fall into the new 1st quadrant when it ranks 1st in multiple criteria? As can be seen from the MDS chart, the two criteria axes of the USA in "Life Style Taste" and "Environment Standard" fall to the left (relative to the origin). In terms of statistical scores, the USA also obtained only 4.99 and 5.31 respectively, which are not outstanding scores. The reason why these two criteria are not prominent may be: compared with other leading design countries, the impression of the United States, whether it is the choice of daily necessities by the American people, or the public space they live in, is not so detailed and sophisticated. In addition, US consumers seem to value price and durability over quality, which may also contribute to the mediocre performance of the relevant criteria.

On the whole, these countries, which are in the leading design group, are very consistent with experts' perception of global design trends. The scores of each criterion and the distribution of MDS can also reasonably explain the design status of each country. The gaps between these countries are very small, and it could be said that the final ranking is determined by very small details.

- Mid-level

South Korea and Taiwan, with overall impression scores of 5.25 and 4.80 respectively, both fall roughly inside or near the new 4th quadrant, which are the mid-level design countries/ regions.

Compared to other countries, South Korea and Taiwan are relatively close on the MDS chart; South Korea is in the new fourth quadrant, and Taiwan is in the third (but next to the fourth). In addition, both of them obtain a mid-level score of about 4 to 5 points in each criterion, so they are classified as "Mid-level" here.

It can be seen from the MDS chart that South Korea and Taiwan are lagging behind the leading group in the four criteria axes of "International Activity", "Designers Level", "Future Trends", and "Historical Impact". South Korea has a better performance than Taiwan, especially in the two criteria of "Life Style Taste" and "Environment Standard", which are not inferior to the USA. The "Mid-level" classification of South Korea and Taiwan from the six criteria echoes their evaluation in "Overall Impression".

The possible reasons for the difference in evaluation between South Korea and Taiwan could be roughly attributable to: (a) South Korea started the development of modernization earlier, (b) international brands such as LG and Samsung, as well as K-pop's global influences, drove the vigorous development of related industries, and (c) Seoul took the lead in taking design as the focus of urban development and improving the design level of various public constructions.

In recent years, Taiwan has vigorously promoted the value of design through the design organization established by the government and has also received a lot of international design awards. However, most of the design activities, exposure, and projects are still confined to the island. International participation is limited to exhibitions, events, international conferences, several specific design awards, etc. Perhaps pushing designers to the international stage will be the key to bringing Taiwan closer to a design-leading country.

- Fall-behind

Turkey, South Africa, and India, with overall impression scores 4.05, 3.96, 3.80 respectively, all fall inside the new 3rd quadrant, and they are the fall-behind design countries. Some of the survey participants responded that they are not familiar with the design status of these countries.

The three countries in this group are all in the new third quadrant of the MDS chart, with Turkey and South Africa being very close, and India alone being the furthest from all other countries. In the descriptive statistics, Turkey and South Africa have scored 3.30~3.92 in each criterion. How to make breakthroughs in any one or two criteria will be the key to whether Turkey and South Africa can advance in the rankings.

The biggest difference between India and the other two countries in this group is in the two criteria of "Life Style Taste" and "Environment Standard". India only obtained the lowest score of all nine countries/regions. This score may correlate to a considerable extent with India's poorer overall economic conditions, quality of life, environmental conditions, etc. How does India use design to transform its international image? An improvement in the overall economy, or a design upgrade for affordable goods, may be more appropriate for the country's current conditions.

The design rankings of the above countries/regions are derived from the MDS spatial distribution of each criterion (f1~f6). The results echo the corresponding overall evaluation values (f0). The leading countries score from the USA (6.04) to Japan (6.27); mid-level includes South Korea (5.25) and Taiwan (4.80); and fall-behind ranges from India (3.80) to Turkey (4.05) (see Table 10).

Table 10. Analysis and comparison of 3 items: "Overall Impression" evaluation, descriptive statistical analysis, MDS.

f0 Overall Impression	6.27	6.13	6.12	6.04	5.25	4.80	4.05	3.96	3.80
MDS New Quadrant	2	2	2	1	4	3	3	3	3
Top Ranking Criteria	f2, f5, f6			f1, f3, f4					
Outstanding Criteria (score > 5)	All	All	All	f1~ f4					
Mediocre Criteria (score 4~5)				f5, f6	All	f1, f2, f3, f5, f6			
Under-performing Criteria (score < 4)						f4	all	all	all
Fall-behind Criteria								f3, f4	f1, f2, f3, f5, f6
MDS Classification	Leading	Leading	Leading	Leading	Mid-level	Mid-level	Fall-behind	Fall-behind	Fall-behind

4.3. Design Awards Ranking vs Design Ranking as Perceived by Experts

This study found that when evaluating the design level of a country, whether it is the overall impression of experts' intuition ("Overall Impression") or the results of questionnaire analysis measured by six criteria, all point to the same conclusion: The leading groups are Japan, France, Denmark, and the USA; the mid-level groups are South Korea and Taiwan; and the fall-behind groups are Turkey, South Africa, and India.

On the contrary, the rankings with the design awards as the only factor (such as: WDR, iF Ranking, and Reddot Design Ranking), it could be found that there is a considerable gap between the ranking results and the design experts' perception of the current status.

Taking WDR as an example, among the 114 countries/regions on the global list, the United States and Japan still occupy the positions of the leading groups (2nd and 3rd, respectively). However, Taiwan in the mid-level group and Turkey in the fall-behind group

are in the Top 10 in WDR (7th and 8th respectively). Even more surprising, India in the fall-behind group ranks much higher on WDR (20th) than the design powerhouses France and Denmark (28th and 61st respectively). Taking the number of design awards as the only criterion for global design ranking, the evaluation results are obviously different from the cognition of design experts (see Table 11).

Table 11. The overall impressions of experts on the design levels of different countries, in comparison with WDR and DCR Ranking.

									
f0 Overall Impression	5.25	6.04	3.80	6.12	4.80	6.13	6.27	3.96	4.05
f1–6 MDS Classification	Mid-Level	Leading	Fall-behind	Leading	Mid-Level	Leading	Leading	Fall-behind	Fall-behind
DCR Ranking 2007	9	7	30	5	18	10	3	41	-
WDR Ranking 2022	17	2	20	61	7	28	3	32	8

The reason for such a gap may be found in the motivation for participating in the design awards. Taking the well known iF, Reddot, G-Mark, and A' as examples, applicants need to fill in many forms and documents and then pay a registration fee to enroll. Therefore, participants in such awards must be motivated enough to be willing to spend considerable time, effort, and expense. Usually, participants of these design awards hope to use the awards to prove their design abilities, or as a means of marketing, publicity, and obtaining subsidies.

Some designers who have established a considerable reputation, or brands and manufacturers who do not need to rely on awards to prove their design quality, are less motivated to apply for these design awards. Therefore, these "Registration System" types of design awards are mainly attracted to those who need to use the awards to establish their own reputation or achieve certain publicity effects.

When the scope of discussion is extended to the national level, those countries or regions that want to gain international recognition and break through the status quo are the most active (such as China and Taiwan); some European countries that have already established themselves as global leaders are not so active. Based on the current situation, Asian countries (especially the Chinese-dominated regions) are the main participants of the design awards, while European countries are relatively indifferent. It is not difficult to understand that those design powerhouses are not outstanding in such awards.

Design awards are attractive to those who hope to gain recognition through awards and obtain some commercial and marketing purposes. There is an interdependent "supply-demand" relationship between design awards and applicants. It cannot be denied that the design award is still an important driving force for improving design. However, winning the award only represents the affirmation of the design, and it cannot be said that the award-winning designs are better than the ones that were not awarded. If this premise is ignored and the number of awards is used as the benchmark for comparison of design capabilities, it will be far from the true purpose and value of the design award and will fall into the myth of chasing awards.

When the results of this study are compared to the DCR, interesting findings emerge. Although the DCR is a ranking from more than a decade ago and uses different criteria, it surprisingly yields similar results. For the sample of nine countries in this study, the ranking order is Japan, France, Denmark, the United States, South Korea, Taiwan, Turkey, South Africa, and India, and the ranking of DCR is Japan, Denmark, the United States, France, Taiwan, India, and South Africa. Among them, Turkey was not found in the DCR 2007 ranking and cannot be compared. The only two groups with slight differences in rankings are South Korea/France and India/South Africa. If the rankings are separated into leading, middle, and fall-behind groups, only South Korea is different.

Considering the time difference of more than ten years, as well as the difference of evaluation criteria and methods, the similarity between the two rankings is worth exploring. This study puts forward the following bold inferences: (1) although many new design fields have sprung up in the past decade, the global design ranking seems to have not changed much. (2) The indicators adopted by DCR are mostly related to industrial and technological innovation, and the evaluators evaluate their own countries, resulting in slight differences in rankings. (3) To some extent, the newly constructed evaluation framework of this study has been verified and supported by DCR.

4.4. The Influence of Each Criterion on the Overall Evaluation

In addition to descriptive statistics and MDS analysis, this study also used ANOVA and regression analysis to find associations between six criteria and overall design evaluation. The relevant findings are as follows:

Overall design evaluation was significantly and positively associated with Criteria 1—"International Activity" in eight of nine countries (South Korea: $p < 0.01$, USA: $p < 0.001$, Denmark: $p < 0.05$, Taiwan: $p < 0.001$, France: $p < 0.001$, Japan: $p < 0.01$, South Africa: $p < 0.001$, Turkey: $p < 0.01$); followed by criteria 2—"Designers Level", which has a significant and positive impact on seven countries (South Korea: $p < 0.01$, USA: $p < 0.001$, Taiwan: $p < 0.01$, France: $p < 0.01$, Japan: $p < 0.01$, South Africa: $p < 0.05$, Turkey: $p < 0.01$); criteria 3—"Future Trends" (South Korea: $p < 0.05$, France: $p < 0.05$, Japan: $p < 0.01$); criteria 4—"Historical Impact" (Taiwan: $p < 0.05$, France: $p < 0.05$, Turkey: $p < 0.05$); criteria 6—"Environment Standards" (Denmark: $p < 0.001$) had a significant and positive impact on the overall design evaluation of one to three countries/regions, respectively; criteria 5—"Lifestyle Taste" did not significantly affect the overall design evaluation of any country/region in this study.

It can be deduced from the above that the overall design evaluation of a country will be greatly affected by the international activity and the level of designers. Due to differences in their background, culture, economy, and other factors, each country's evaluation is affected by the criteria differently. For example, Denmark was the only country whose overall rating was significantly affected by the "Environment Standard" ($p < 0.001$). The respondents had a very good impression on the design standards of Denmark's architecture, transportation, public construction, etc., which positively affected the overall evaluation of Denmark.

"Future Trends" has a significant impact on the overall evaluation of Japan, South Korea, and France (Japan: $p < 0.01$, South Korea: $p < 0.05$, France: $p < 0.05$). Japan and South Korea are in a leading position in futuristic fields, such as high-tech and interactive design; French design has an avant-garde and experimental style. These are all key factors contributing to the overall high evaluation of the above-mentioned countries.

4.5. The Influence of Subjectivity and Objectivity on Evaluation

The authoritative QS ranking of global design schools, the T10 design ranking of global cities, and the design ranking among countries in this study all rely heavily on the experts' impressions of the evaluated objects.

Due to the shortage of manpower, funds, resources, etc., it is quite difficult to obtain objective information and data from various countries. This research has to conduct questionnaires without providing background information. As some compensation, there is no limit to the response time, nor does it limit the possibility of respondents to find reference materials. Interestingly, respondents still mostly rely on their own impressions of the subjects to respond.

How do international organizations with relatively adequate resources deal with similar issues? For QS, there are a total of five criteria. Among them, "Academic Reputation" is a list of domestic and foreign schools that respondents think are excellent in this field (except their own schools). "Employer Reputation" is a list of domestic and foreign schools that respondents (employers) consider excellent or prefer when considering employment. This list is without the channeling for different faculty areas [17].

T10 also uses a similar method. After formulating the evaluation criteria, nearly a hundred design experts are asked to propose the most suitable cities in their minds, and then the ranking is calculated.

The above assessment methods have a considerable degree of subjective components. Could these subjective impressions lead to biased or misinterpreted assessment results? Subjective impressions are based on respondents' observations, learning, contacts, and interactions with the object over many years, and are influenced by factors such as education, culture, life, and work experience. Judgments based on the accumulation of these experiences can also be said to be framed by some objective content.

Subjective judgments, especially those from experts, have long been an important basis for design rankings. However, there is indeed an effect of familiarity with the subject being assessed. Therefore, ranking the leading group in this way is very effective; but, for the evaluation of the mid-level or fall-behind group, there may be a possibility of a decline in discrimination due to lack of familiarity.

The quality of the design is difficult to quantify, so it still relies on the subjective judgment of experts. Design evaluations that rely on subjective impressions may be imperfect but are still necessary until a better way emerges. In order to avoid bias caused by a small number of individuals, it is best to obtain a certain number of experts to participate in the evaluation and achieve sufficient consensus to make the results more reliable and authoritative.

4.6. The Impact of Outstanding Performance in a few Fields on the Overall Evaluation

The evaluation framework adopted in this study mainly refers to the mechanism of QS and T10, and the evaluation is carried out based on the overall design status of a country. Various design fields of a country (e.g., visual, product, interior, architecture, digital, fashion, etc.) are covered.

Respondents may be familiar with one or more specific design field(s) of a country, but not others. In this case, they may rate based on their impressions of the familiar domain(s), a situation that is prone to bias.

Existing design evaluation mechanisms (such as: WDR, WDC, T10, QS, etc.) are often used as a reference for evaluating the design level of countries, cities, schools, etc. Several of them have been regarded as authorities in the field. For example: QS has always been the most important and even the only reference for many design students when choosing schools. However, these evaluation mechanisms are based on the overall design level and are not subdivided by design fields. Therefore, the bias mentioned here is inevitable. Outstanding performance in a few field can lead to an overall evaluation advantage.

The New School (Parsons School of Design, hereinafter referred to as Parsons) has been ranked among the top three in the QS world rankings for many years. Although the design departments of Parsons are generally well-received, the most prominent and internationally renowned ones are only a few, such as fashion. National Cheng Kung University mainly focuses on science and engineering, but due to the outstanding performance of a few design departments, such as architecture and industrial design, it was shortlisted in the QS Global Top 100. The case of National Taiwan University is even more peculiar. Just by offering courses such as Design Thinking at Stanford D-School, it has also entered the QS Top 100 rankings without a substantial department [17].

A similar situation was encountered in the process of this research. Some respondents said that they gave relatively high marks to Denmark, mainly because they were impressed by the classic Danish furniture design. Respondents, however, were less familiar with other fields of design in the country.

If the design field is not subdivided, the above results are inevitable. To reduce this kind of bias, it is necessary to conduct individual evaluations by field, and then calculate them collectively. However, the investment of time, manpower, resources, and other costs can also be quite considerable.

5. Conclusions, Implications, and Limitations

5.1. The Design Award Cannot Comprehensively Reflect the Real State of the Design World, Which Is the Inevitable Result of its Own Structure

This study found that when the number of design awards is used as the only criteria for global design ranking or evaluation, the results will have a considerable gap with the perception of experts. This kind of ranking mechanism ignores many other more important factors and is only the result of comparison among applicants. For those who have not registered for various reasons, the fairness of the competition in the same field is completely excluded.

Winning the design award can only mean that a relatively high-quality design was selected among the works submitted at that time. To be more precise, the works that better met the selection criteria and the appeal of the design award were selected. As for those designs that were not submitted due to various factors, no comparison can be made through this type of mechanism. Therefore, snubs are a natural occurrence of design awards.

If the number of design awards is used as the benchmark for the evaluation of a unit, more caution is required. Due to the different representation and significance of each award, none of the awards is comprehensive enough, and most of them can only reflect the design status of a certain aspect.

Based on the above, this study believes that the design award cannot fully reflect the real design situation, which is a structural necessity. Using the number of design awards as a criterion for evaluating a country's design level can easily lead to bias. In addition, due to differences in motivation, countries with different design development status have significant gaps in their willingness to participate in the design awards. This type of design award evaluation mechanism lacks fairness and comparability for all designs to compete on the same stage. Therefore, the design award is not appropriate as a single or primary criteria for assessing the level of design across countries.

Although this study only uses the country as the unit of comparison, it can be boldly speculated with the same logic: when the evaluation unit is replaced (such as: school, city, etc.), similar conclusions could also be obtained.

5.2. 6 Criteria for Evaluating the Design Level of a Country

It is inappropriate to use the number of design awards as a benchmark for global design evaluation, and other more influential evaluation mechanisms are also lacking. Therefore, this study attempts to construct a new evaluation mechanism. According to the theoretical basis of "Grounded Theory", expert interviews were conducted, and six indicators were summarized: international activity, designers' level, future trends, historical impact, lifestyle taste, and environment standards. Questionnaire surveys and statistical analysis were conducted using these six criteria, and the results echoed the overall design evaluations of design experts.

The six criteria affect the overall design evaluation of each country to varying degrees. Almost every country has been significantly influenced by "International Activity" and "Designers Level". However, due to differences in background, culture, economy, etc., they are influenced by other individual criteria to varying degrees. If policy makers want to improve the overall evaluation status of their countries, they can refer to the framework proposed in this study and strategically focus on criteria with a high degree of influence and optimize the use of resources.

5.3. Reflections on Taiwan's "Design Award Phenomenon"

The "Design Award Phenomenon" mentioned in this study is most pronounced in Asian countries/regions, such as Taiwan. The government cites the number of design awards as a symbol of national "design power", and it is also an important criterion for evaluating design companies and design schools. The craze for design awards has become a collective social phenomenon.

According to the research of "Taiwan Design Power Report 2019", two contradictory phenomena have been discovered: (1) Taiwanese designers hope that by winning international

design awards, they can obtain benefits such as increased prestige and free publicity. More than 80% of them have participated, and 1/5 of them participate regularly every year. (2) Design awards are not the primary consideration when design firms measure their own performance [2].

Why are so many Taiwanese design companies willing to spend time and money to participate in design awards that are not the primary consideration for performance? Part of it comes from peer competition (other design companies are fighting for it, it seems that it is impossible not to obtain it), and part of it comes from customer requirements (the winning design is easier to market). Of course, it is also due to the lack of objective understanding of good designs/designers/design companies (without seeing the award-winning qualifications, and it is difficult to conclude that it is a good design/designer/design company). The reasons for pursuing the design award are quite helpless, and it is difficult to directly convert the awards and cash them in the actual revenue, which creates a dilemma and forms a vicious circle.

A similar situation has also occurred in Taiwan's academic circles. The number of design awards is used as the benchmark for evaluation of design schools, and even the promotion conditions for professors. An educational policy targeting design awards does have the potential to stimulate students to create better designs, and it is easy to review the results in the short term. However, too much emphasis on winning prizes may crowd out other values that need to be taught in the design education process.

The real challenges of a design career are the problems, changes, and complex realities that students are bound to encounter after graduation. If students have a solid foundation, a correct perspective, and a macroscopic vision of the world, they will have a better chance of survival and the ability to cope with and adapt to the real world. These are aspects of design education that cannot be taught through technical aspects but should not be overlooked.

In Taiwan, the phenomenon that the number of design awards is used as the benchmark for measuring individual, collective, and even the overall national design level has been regarded as the norm. Although it brings considerable convenience to the evaluator, it ignores many other more important design aspects. The lack of supporting facilities after the award also makes it difficult to extend the value after the goal is achieved. According to this study, this evaluation mechanism is prone to bias, and there is a significant gap between the evaluation results and the cognition of design experts.

In Taiwan, the pursuit of design awards has its historical and political backgrounds, and it is undeniable that it has significance and value at that time. However, if the authorities want to make real breakthroughs in design, they must dispel the myth of the "Design Award Phenomenon" and face up to the real issues. Only in this way is there a good start for the long-term development of design.

5.4. Theoretical Implications

This study questions the mechanism of WDR, which uses the number of design awards as the benchmark for global design ranking and examines the rationality of the structure through questionnaires and statistical analysis. The conclusion shows that the number of design awards is not suitable as a single or main benchmark for evaluating national design capability. In addition, this study attempts to establish a new evaluation mechanism. Through expert interviews and consensus meetings, six criteria were summarized.

Through questionnaires and statistical analysis, it is confirmed that the evaluation results of the six criteria can meet the cognition of design experts. Design scholars, practitioners, or relevant stakeholders can use this framework as a foundation to develop a more comprehensive and fair evaluation mechanism.

5.5. Practical Implications

Design-related stakeholders, such as practitioners, educational institutions, promotion organizations, policy makers, etc., can use the framework of this research to evaluate the design level of their own countries and to examine which factors have a greater impact on

the evaluation. The future design strategies developed for these orientations can optimize the use of resources.

5.6. Limitations and Improvements

Limited by factors such as manpower, time, and financial resources, and the complexity of collecting objective data from various countries and conducting questionnaires, this study was conducted without reference materials. The questionnaire is conducted in Chinese, and the respondents are mostly Chinese living in China, Taiwan, Malaysia, and the United States. Although we try to invite experts with a more international perspective, there are still some doubts about the homogeneity. If the evaluation results are to be more macroscopic and diverse in the future, it is suggested that design professionals from more countries, regions, and fields should participate.

If funding, manpower, time, and other conditions permit, it is possible to further improve the accuracy of relevant evaluations and reduce the bias of the research caused by subjective impressions, familiarity, and other factors.

For future research, it is suggested that the following methods can be used for further optimization: (1) diversified backgrounds: the diversity here refers to the nationality, region, professional field, etc. of the respondents; (2) objective data: reduce bias caused by subjective impressions; (3) sub-domain evaluation: first conduct evaluations in different design fields (such as: graphic design, product design, fashion, architecture, digital, etc.), and then synthesize the results.

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