

Article

Analysis of Key Factors for XR Extended Reality Immersive Art Experience

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Abstract: We examined the perception and preference of extended reality (XR) immersive art experiences from the exhibition at the National Taiwan Science Education Center between October 2021 and February 2022. Various research methods including a questionnaire survey, expert interviews, on-site observation survey, and triangulation were used to analyze qualitative and quantitative results. Structural Product and Service Solutions Principal Component Analysis (SPSS PCA) was also used to analyze and validate a sample of 219 participants. The findings indicated that the participants' preference and ranking results were in line with the TeamLab Planets exhibition held at the National Taiwan Science Education Center. The key factors of immersive experience were charm and elegance, artistic and technological innovation, creativity and professionalism, trendy and cool, and eye-catching and exquisite immersion. These results served as a reference and contributed to understanding the current trends in immersive art experience design.

Keywords: XR extended reality, Immersive art experience, TeamLab Planets, Key factors

1. Introduction

In the post-pandemic era, sustainable design research has become increasingly important, and interdisciplinary research becomes the key to combining information visualization, ecological environment, energy, and environmental protection through Kansei design. The TeamLab Planets exhibition is a unique environment that combines art and digital technology. Participants can traverse the space without a fixed route, and digital projections and lighting respond to participants' movements (TeamLab Planets, 2023). The uniqueness of this museum is that it does not display any physical artworks, but more than 50 digital artworks make it a world-leading digital art creation. The TeamLab Planets team consists of "super technical experts" from various fields, including CG animators, engineers, artists, architects, mathematicians, and other professionals. They use collective expertise to create a beautiful and dreamlike ultra-dimensional space, providing an amazing immersive art experience. The museum is located on an artificial island in Tokyo Bay and is jointly operated by Mori Building and the internationally renowned art group TeamLab Planets, adding to the museum's appeal. It is Japan's largest digital art museum and the TeamLab Planets' permanent museum in Tokyo (Oen et al., 2020). The TeamLab Planets museum not only displays digital art but also explores new relationships between humans and nature, and humans and the world. They use the most advanced digital technology to get rid of the limitations of material frameworks, making digital art not only exist in pictures but also become a perceptible experience in space. The team's exploration of the intersection of art, design, science, technology, and nature reshapes cognition through intuitive Kansei experiences by breaking human limits and cognition of the world and time. This form of art is not only contemporary art but can also be seen as future art that surpasses the past. The TeamLab Planets museum has received international attention, and its works are permanently collected by major art institutions such as the New South Wales Art Museum, South Australia Art Museum, San Francisco Asian Art Museum, and Turkey's Borusan Contemporary Art Collection Museum. They continue to be invited to exhibit around the world, including the TeamLab Planets Supernatural Space permanent exhibition, which opened in June 2020 at The Venetian Macao, and the "Every Door is Door" joint exhibition and "The Master" Shanghai "Shower³ by TeamLab Planets" exhibition held in Miami. In this study, we explored the attractiveness and preferences of immersive art interactive experiences exhibited at the National Taiwan Science Education Center in Taiwan from October 2021 to February 2022 (TeamLab Future Park, 2021). Under the interactive digital innovation model, participants experienced TeamLab Planets' art and technology entertainment through innovative sustainability and perceptual charm, including the promotion of cultural economy, the transformation of art aesthetics, and the innovative integration of perceptual charm design, driving industry value. The main plan of TeamLab Planets in the National Taiwan Science

Education Center's themed exhibition "Borderless" includes "Animals of Flowers Born in the Flower Forest, Symbiotic Lives," "Forest of Flowers and People: Lost, Immersed and Reborn," "TeamLab Planets Athletics," and "Future Park. " Another important work in the exhibition hall is "Graffiti Nature-Mountain and Valley, Red List," which introduces ecological cycles and endangered species into space through digital graffiti, and on-site graffiti creation becomes part of the digital natural world through digital processing. Based on the design of the extended reality (XR) extended reality experience, we conducted interviews and then explored the perception and humanistic design of the XR extended reality experience through factor analysis (Ratclie et al., 2021). The survey result of participant preferences can serve as a reference for exploring key factors in XR extended reality experiences in the future. We focused on understanding the visual images and participants' preferences in this study.

2. Materials and Methods

2.1. XR Extended Reality Digital and Mixed Reality Experience

Azuma (1997) published a survey on augmented reality (AR) and virtual environments, exploring applications in healthcare, manufacturing, visualization, entertainment, and the military. This survey served as a starting point for research on AR. The XR extended reality experience utilizes both sound and visual digital technologies (Kettunen and Oksanen, 2018). It includes AR (Kettunen and Oksanen, 2018), virtual reality (VR) (Radianti et al., 2020; Panagiotis et al., 2020), as well as the latest version of VR technology and mixed reality (MR) (Blascovich, 2002; Raphael et al., 2018). They have become a mature technology, increasingly applied in enterprises, healthcare (Gromala et al., 2015), art performance (Choi et al., 2016), and exhibition display (Khalil, Kallmuenzer, and Kraus, 2023). XR extended reality experience employs sound and visual digital technology (Kettunen and Oksanen, 2018), including AR (Kettunen and Oksanen, 2018), VR (Radianti et al., 2020; Panagiotis et al., 2020), and MR (Blascovich, 2002; Raphael et al., 2018). The TeamLab Planets exhibition hall has formed a unique style of XR extended reality experience through ecology and education systems, directly affecting the emotional needs of participants. According to the global survey of the XR industry, XR extended reality reflects a mature technology in the healthcare industry (XR Express Taiwan Startup Log, 2021). Virtual reality (VR) technology's visual accuracy and perception have applications in psychology (Wilson and Soranzo, 2015), art (Kilteni, Bergstrom, and Slater, 2013) and allows exhibition display with a more realistic presentation of the environment and stimuli (Khalil, Kallmuenzer and Kraus, 2023). In technology-based digital learning (Brookes et al., 2019; Radianti, 2020), XR extended reality experiences can also be used for aesthetic and educational purposes. The strategic goal of the XR extended reality experience project is to enhance the financial capacity of local governments and promote local economic development by revitalizing the business environment (Statista, 2022). In Taiwan, after the COVID pandemic, demand has increased in five key areas: games, media broadcasting, education, exhibitions, and audio-visual entertainment (XR Express Taiwan Startup Log, 2021). Thus, the projects also increase the link between the business environment and community living environment, enabling development towards the sustainable management and cycle of culture and economic development.

2.2. Kansei Engineering and Qualia

Kansei engineering focuses on consumers' psychological feelings and emotions. It translates consumers' senses and intentions into design elements that can be felt in the user's mind when they use the product. By understanding users' emotional needs and perceptual responses, designers can create products that meet real desires (Djatna and Dwi Kurniati, 2015). This approach has been successfully used in various fields such as product design, advertising, and architectural design (Nagemachi, 1989). The Qualia branding project highlights the value of products which is not determined solely by their features and specifications but by the Kansei elements of interactive technology. The project has been applied in many fields, including project design, advertising, and architectural design (Yen, Lin, and Lin, 2013). Izumi launched the Qualia branding project in 2001 to emphasize how the value of future products was determined by Kansei elements, not only features and specifications (Yen, Lin, and Lin, 2015). The effective measurement model was used to determine consumer needs, and product design is based on consumer preferences and purchase intentions in the project. The five Qualia factors included attractiveness, beauty, creativity, delicacy, and engineering (Yen, Lin, and Lin, 2015). Participants focused on the dramatic experience and the authenticity of the characteristics of different preferences were analyzed. Digital art museums without physical works provided an amazing immersive art experience. By applying advanced digital technologies to the presentation of new forms of artistic expression, participants could experience immersive art, and Qualia design co-created an interactive exploration of art, science, technology, and auto biomimetic design in line with Maslow's hierarchy of needs (Maslow, 1943). Their technology and art-immersive experiential exhibitions were known for their bright colors, fun, individuality, differentiation, and psychological depth, all of which met the unique needs of an art-immersive experience. Based on the project's outcomes, we discussed the needs and preferences of participants from a perceptual perspective and analyzed current trends in the value of XR extended reality experiences.

2.3. Experience Value

Experiential value refers to participants' satisfaction with their experiential and emotional needs during an experiential activity. It involves creating products and services that provide a fully stimulating environment to enjoy (Sundbo, Jon, and Soresen, 2013). The unique needs and values desired by participants are translated into unforgettable experiences. This concept has been applied in various industries, including tourism, entertainment, and retail (Sheth, 1991). The strategic experience module is when consumers are motivated to identify a product or consume it by experiencing or observing it first-hand, which enhances the product's value (Schmitt, 1999). The experience is the process of transforming the unique needs and values that consumers expect from participants into an unforgettable experience that comes from personal psychological states and interactions with events. The positive side of the experience includes the educational experience of wanting to learn, the escapist experience of not wanting to do something or escape, the entertainment experience of wanting to enjoy a certain feeling, and the aesthetic experience of being in an aesthetically pleasing scene (Pine II and Gilmore, 1999). Companies use services as the stage, goods as props, and consumption as the center to create engaging and memorable engagements (Pine II and Gilmore, 1999). Experiential cognition was a psychological process of perception that also occurs through the perceptual system (including sight, touch, hearing, taste, and other sensations and ideas) (Pine II and Gilmore, 1999). Subjective and personalized, the experience is not only emotionally charged but also includes learning and activities to create values that remain in the memory of the participant after the experience activity is ended.

2.4. Immersive Art Experience

According to Csikszentmihalyi, the 'Flow Experience' is a state of complete immersion in an activity in which an individual's skills are perfectly matched to the challenge, bringing deep satisfaction and pleasure. In visual arts, sensory sensations such as visual, auditory, and tactile stimuli generate emotional pleasure, ease, and wonder which produce an immersive experience with a realistic and lifelike feeling (Csikszentmihalyi, 1996). VR has a positive impact on the learning experience with the flow experience moderating learning and increasing students' motivation, curiosity, cognitive benefits, reflective thinking, and perception of value. These findings suggest that virtual reality technology has applications in art and design learning and offers the potential to enhance the teaching and learning experience (Guerra-Tamez, 2023). Art with technology incorporates a variety of new technological means, visual representations of virtual images, and realistic environments that are subtly integrated to present aesthetics and interactive art and make the participant feel something (Saltz, 1997). Gao (2022) explored the transformation of traditional art exhibitions in the age of immersive media from three perspectives: display methods, forms of information delivery, and aesthetic experiences. The immersive art experience is a visual art experience that allows for a state of mind in which the participant has a sense of immediacy, freedom, and wonder.

2.5. TeamLab Planets

The TeamLab Planets Digital Art Museum combines technology, art, and nature to create innovative, interactive digital artworks in collaboration with participants (Oen and Jacobson, 2020). The museum's team of "super technologists" use advanced digital technology to create beautiful, dreamlike spaces that provide an immersive, sensory art experience (Rogers and Ariel, 2019). By exploring the intersection of art, design, science, technology, and nature, the museum challenges the perceptions of the world and time through an intuitive sensory experience. Each exhibit blurs the line between virtuality and reality and encourages participants to become a part of the artwork by continuously transforming the images of the works through their actions (TeamLab Planets, 2023). Through analysis of TeamLab Planets' work, characteristics are identified as highly interactive and participatory, allowing viewers to interact with the artwork through touch, sound, light projection, and a vibrant virtual nature scene that blends technology and natural elements (TeamLab Planets, 2023). In this study, we conducted research on the psychological aspects of consumer attitudes toward XR and art experiences and the emotional and psychological needs of consumers that influence consumer behavior.

Focusing on the TeamLab Planets exhibition at the National Taiwan Science Education Center, we determined the key factors that attracted participants to the exhibition and the immersive art experience to understand the visual impressions of participants and identify their preferences for the exhibition theme and other suggestions. The results can be used as a reference for future designers. Based on the literature review, we also examined the factors in the visual imagery of TeamLab Planets and identified the future design quality.

3. Research Process

3.1. Research Framework

We researched the TeamLab Planets exhibition at the National Taiwan Science Education Center with the research subjects of the participants who visited the exhibition. The research methods included expert interviews, on-site observation surveys, and triangulation verification. Firstly, using the KJ method, five experts were invited for semi-structured qualitative interviews. The KJ method is to organize thoughts based on unknown problems or related opinions, facts, or concepts. According to the participants' immersive art experience, a questionnaire survey was conducted for them. Data were analyzed with factor analysis to determine appropriate designs and suggestions for modification (Scupin, 1997). The data included 198 perceptual words, and appropriate words were selected by calculating the total score. Then, another questionnaire survey was conducted for participants who had visited the TeamLab Planets exhibition at the National Taiwan Science Education Center to know their age, gender, education level, income status, and adjectives to describe their experiences. A Likert scale with five levels (1 strongly disagree, 2 disagree, 3 agree, 4 strongly agree, 5 very strongly agree) was adopted, and favorite themes and suggestions were asked.

3.2. Interview

A questionnaire survey was conducted for participants who visited the TeamLab Planets exhibition at the National Taiwan Science Education Center. The survey included emotional and favorite thematic parts to determine 35 perceptual adjectives. Then, a formal questionnaire survey was conducted, and 219 valid questionnaires were obtained. With factor analysis with SPSS, potential factors were extracted for measurements with common characteristics to determine the main factors for subsequent data analysis. Based on the results, the perceived needs that the participants explored and the attractiveness factors that enhanced their preferences were summarized. In this study, we (1) determined research objectives, (2) designed research tools, (3) collected data, (4) conducted interviews and questionnaire surveys, and (5) analyzed results. Thirty-five factors were selected from 198 perceptual words such as “tasteful, fascinating, charming, styling, high-end, vibrant, fashionable, textured, colorful, unique, noble, three-dimensional, artistic, visual impression, interactive, techno-entertainment, design-oriented, innovative, digital, immersive, dynamic, modern, diverse, creative, professional, interesting, technological, novelty, fantastic, cool, avant-garde, dazzling, trendy, eye-catching, and exquisite.” These descriptive words were summarized into nine themes which were included in the factor analysis questionnaire design. The decision-making process for factor analysis included the following process: (1) setting the goal of factor analysis, (2) designing factor analysis, (3) proposing hypotheses for factor analysis, (4) deriving factors and evaluating overall fit, (5) explaining factors, (6) verifying factor analysis, and (7) analyzing results of factor analysis. According to the participants' immersive art experience, a questionnaire survey was conducted to verify the reliability and validity to confirm the appropriateness of conducting factor analysis. The result of factor analysis was used to identify the main common factors of the interviewees' perceptions and to classify the classifications.

4. Result and Discussion

4.1. Quantitative Result

The questionnaire survey result showed the information with reliability and confidentiality. To reduce the issue of Common Method Variance (CMV), the survey was conducted anonymously. The primary scores were used to define the conceptual model. Harman's single-factor approach and the statistical remedies technique were used to assess the reliability and validity of the relationships and constructs (Podsakoff et al., 2003). When a single factor explained less than 50% of the total variance, CMV was not a concern in this study.

219 valid questionnaires were returned from 130 females and 89 males. The participants were selected randomly (Chang, 2017). The age of the participants ranged from under 20 to over 65 years old (under 20 years old (12.3%), 21–30 years old (44.7%), 31–50 years old (22.8%), 50–65 years old (18.7%), and over 65 years old (1.4%)). The level of education was graduating high school or vocational high school (10%), university degree (37.4%), master's degree (43.8%), and Ph.D. degree (8.7%). Monthly income levels were below NT\$20,000 (41.6%), NT\$20,000 to 40,000 (18.7%), NT\$40,000 to 80,000 (19.2%), and NT\$80,000 and above (20.5%). Factor analysis with 35 perceptual adjectives was conducted using SPSS. The analysis result showed that each of the KAISER-Meyer-Olkin (KMO) scales exceeded the recommended levels, the Bartlett χ^2 of the scale was statistically significant, the validity and reliability of the composite scale exceeded the Nunnally recommended level of 0.6, and the single-factor characteristic values exceeded the recommended level of 1.00. This result validated the significance of the factor analysis.

The Cronbach's alpha was 0.944 so the reliability was acceptable and the factor analysis was conducted. Principal Component Analysis (PCA) and Varimax rotation were used in the factor analysis for consensus construction. The KMO value was 0.946 and

Bartlett's test result was 0.00 which were significant. Therefore, the scale met the criteria for factor analysis. 35 perceptual adjectives were classified into five factors with eigenvalues greater than 1. After rotation, the total variance explained by the five factors was 67.432% (Hair et al., 2010; Heri, 2017). The results are shown in Tables 1 and 2.

Table 1. Total variance .

| Perceptual adjectives | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
|-----------------------|---------------------|---------------|--------------|-------------------------------------|---------------|--------------|-----------------------------------|---------------|--------------|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| Tasteful | 16.506 | 47.161 | 47.161 | 16.506 | 47.161 | 47.161 | 6.889 | 19.683 | 19.683 |
| Fascinating | 3.242 | 9.262 | 56.424 | 3.242 | 9.262 | 56.424 | 6.202 | 17.721 | 37.404 |
| Charming | 1.622 | 4.635 | 61.059 | 1.622 | 4.635 | 61.059 | 4.793 | 13.694 | 51.098 |
| Styling | 1.191 | 3.404 | 64.463 | 1.191 | 3.404 | 64.463 | 3.667 | 10.477 | 61.575 |
| High-end | 1.039 | 2.969 | 67.432 | 1.039 | 2.969 | 67.432 | 2.050 | 5.857 | 67.432 |
| Vibrant | 0.827 | 2.363 | 69.795 | | | | | | |
| Fashionable | 0.767 | 2.192 | 71.987 | | | | | | |
| Textured | 0.705 | 2.013 | 74.000 | | | | | | |
| Colorful | 0.640 | 1.828 | 75.828 | | | | | | |
| Unique | 0.633 | 1.809 | 77.637 | | | | | | |
| Noble | 0.610 | 1.744 | 79.381 | | | | | | |
| Three-dimensional | 0.577 | 1.648 | 81.029 | | | | | | |
| Artistic | 0.496 | 1.417 | 82.446 | | | | | | |
| Visual impression | 0.489 | 1.397 | 83.843 | | | | | | |
| Interactive | 0.456 | 1.302 | 85.145 | | | | | | |
| Techno-entertainment | 0.429 | 1.225 | 86.370 | | | | | | |
| Design-oriented | 0.410 | 1.173 | 87.543 | | | | | | |
| Innovative | 0.378 | 1.080 | 88.623 | | | | | | |
| Digital | 0.371 | 1.060 | 89.684 | | | | | | |
| Immersive | 0.343 | 0.979 | 90.662 | | | | | | |
| Dynamic | 0.326 | 0.932 | 91.594 | | | | | | |
| Modern | 0.318 | 0.907 | 92.501 | | | | | | |
| Diverse | 0.293 | 0.836 | 93.337 | | | | | | |
| Creative | 0.286 | 0.818 | 94.155 | | | | | | |
| Professional | 0.259 | 0.740 | 94.896 | | | | | | |
| Interesting | 0.240 | 0.685 | 95.581 | | | | | | |
| Technological | 0.224 | 0.640 | 96.221 | | | | | | |
| Novelty | 0.216 | 0.617 | 96.838 | | | | | | |
| Fantastic | 0.200 | 0.572 | 97.409 | | | | | | |
| Cool | 0.189 | 0.539 | 97.948 | | | | | | |
| Avant-garde | 0.176 | 0.503 | 98.451 | | | | | | |
| Dazzling | 0.151 | 0.431 | 98.883 | | | | | | |
| Trendy | 0.146 | 0.417 | 99.300 | | | | | | |
| Eye-catching | 0.129 | 0.369 | 99.669 | | | | | | |
| Exquisite | 0.116 | 0.331 | 100.000 | | | | | | |

Extraction Method: Principal Component Analysis.

Table 2. Matrix after rotation.

| | Mean | Std. Deviation | Component A | Component B | Component C | Component D | Component E |
|----------------------|-------|----------------|-------------|-------------|-------------|-------------|-------------|
| Tasteful | 3.700 | 0.823 | 0.810 | | | | |
| Fascinating | 3.690 | 0.874 | 0.785 | | | | |
| Charming | 3.690 | 0.792 | 0.741 | | | | |
| Styling | 3.670 | 0.825 | 0.736 | | | | |
| High-end | 3.810 | 0.807 | 0.708 | | | | |
| Vibrant | 3.770 | 0.792 | 0.659 | | | | |
| Fashionable | 3.710 | 0.844 | 0.591 | | | | |
| Textured | 3.880 | 0.745 | 0.582 | | | | |
| Colorful | 3.840 | 0.782 | 0.543 | | | | |
| Unique | 3.890 | 0.828 | 0.524 | | | | |
| Noble | 3.710 | 0.832 | 0.523 | | | | |
| Three-dimensional | 4.050 | 0.721 | | 0.772 | | | |
| Artistic | 4.050 | 0.768 | | 0.749 | | | |
| Visual impression | 4.110 | 0.704 | | 0.743 | | | |
| Interactive | 4.190 | 0.708 | | 0.735 | | | |
| Techno-entertainment | 4.170 | 0.682 | | 0.715 | | | |
| Design-oriented | 4.000 | 0.710 | | 0.689 | | | |
| Innovative | 4.040 | 0.673 | | 0.531 | | | |
| Digital | 4.180 | 0.711 | | 0.517 | | | |
| Immersive | 3.970 | 0.763 | | 0.505 | | | |
| Dynamic | 4.020 | 0.674 | | | 0.666 | | |
| Modern | 4.160 | 0.684 | | | 0.644 | | |
| Diverse | 4.080 | 0.703 | | | 0.609 | | |
| Creative | 4.130 | 0.681 | | | 0.606 | | |
| Professional | 4.010 | 0.751 | | | 0.581 | | |
| Interesting | 4.050 | 0.702 | | | 0.552 | | |
| Technological | 4.110 | 0.788 | | | 0.526 | | |
| Novelty | 4.170 | 0.700 | | | 0.507 | | |
| Fantastic | 4.020 | 0.738 | | | 0.506 | | |
| Cool | 3.860 | 0.812 | | | | 0.693 | |
| Avant-garde | 3.930 | 0.748 | | | | 0.672 | |
| Dazzling | 3.670 | 0.868 | | | | 0.622 | |
| Trendy | 3.770 | 0.781 | | | | 0.547 | |
| Eye-catching | 3.730 | 0.770 | | | | | 0.575 |
| Exquisite | 3.800 | 0.782 | | | | | 0.542 |

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a Rotation converged in 19 iterations.

4.2. Results

The perceptual survey revealed the following perceptual factors of the TeamLab Planets exhibition hall for nine thematic zones. Through the factor analysis, five principal components were determined with component A explaining 6.889% of the variance and 19.683% of the total variance. The theme of the venue was “Charm and Elegance” which included tasteful, fascinating, charming, styling, high-end, vibrant, fashionable, textured, colorful, unique, and noble which were appealing to participants of all ages with an atmosphere of collaboration and entertainment. Component B explained 6.202% of the variance and 17.721% of the total variance including three-dimensional, artistic, visual impression, interactive, techno-entertainment, design-oriented, innovative, digital, and immersive which provided participants with an atmosphere of artistic beauty and impressiveness, hence named “Artistic and Technological Innovation”. Component C explained 4.793% of the variance and 13.694% of the total variance including dynamic, modern, diverse, creative, professional, interesting, technological, novelty, and fantastic which provided participants with an atmosphere of interaction and creative collaboration, emphasizing the value of natural worlds and the importance of protecting natural ecosystems, hence named “Creativity and Professionalism”. Component D explained 3.667% of the variance and 10.477% of the total variance including cool, avant-garde, dazzling, and trendy which provided participants with an exquisite design atmosphere through changing sounds and lights and the projection effect of the combination of virtual and reality, hence named “Trendy and Cool.” Component E explained 2.505% of the variance and 5.857% of the total variance including eye-catching and exquisite allowing participants to experience painted works of collaborative creations through technology in an atmosphere of exquisite charm, hence named “Eye-Catching and Exquisite.” The results of the questionnaire survey showed a rank in order of preference for the nine thematic zones of the TeamLab Planets exhibition hall as shown in Table 3.

Table 3. Ranking of nine thematic zone preference

| Rank | Ranked in order of preference for 9 thematic zone | N | Percentage% |
|--------------|---|-----|-------------|
| 1 | Light ball Orchestra. | 36 | 16.438 |
| 2 | Story of the time when gods were everywhere. | 34 | 15.525 |
| 3 | Hopscotch for geniuses. | 32 | 14.612 |
| 4 | Graffiti nature: lost, immersed, and reborn list. | 29 | 13.242 |
| 5 | Sketch animals. | 26 | 11.872 |
| 6 | A table where little people lives | 19 | 8.676 |
| 7 | Sliding through the fruit field | 18 | 8.219 |
| 8 | Animals of flowers, symbiotic lives II | 14 | 6.393 |
| 9 | Sketch animals papercraft. | 11 | 5.023 |
| Total | | 219 | 100% |

Based on the survey results, the favorite themes of the participants were investigated and their preferred nine thematic zones were arranged. The thematic zones for participants are as follows.

- (1) Light Ball Orchestra was the most popular project with the preference of 36 participants, accounting for approximately 16.438%. The project used technology and creative techniques by placing chips inside the ball which changed the color and sound when touched or rolled and played music. It was impressive in the participants’ experience with innovation.

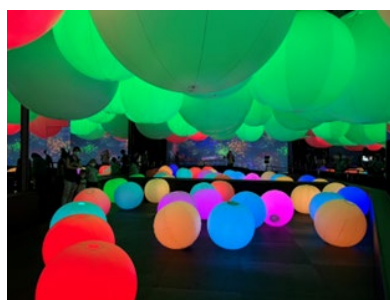


Fig. 1. Light ball orchestra.

- (2) The second popular project was ‘The Story of the Time When Gods Were Everywhere’ favored by 34 participants, accounting for approximately 15.525%. When touching the symbols on the touch screen, the text reacted and created metaphors. It cultivated cognitive ability, pictographic concept, causal relationship understanding, and light-shadow concept for participants’ experience.



Fig. 2. Story of the time when Gods were everywhere.

- (3) Hopscotch for geniuses was the third most popular project selected by 32 participants, accounting for approximately 14.612%. It was an interactive game of jumping and walking that combined colors, symbols, and sounds. It cultivated balance, graphic recognition, the ability to validate hypotheses, and coordination with high artistic experience and entertainment value.



Fig. 3. Hopscotch for geniuses.

- (4) ‘Graffiti nature: lost, immersed, and reborn-red’ was the fourth most popular project selected by 29 participants, accounting for approximately 13.242%. Participants drew animals, and flowers that create a natural world that grows, reproduces, and disappears. It cultivated spatial awareness, ecological awareness, creativity, expression, respect for diversity, self-efficacy, and interest in technology through collaborative creation to learn from nature through experience, inspires, and has innovation in artistic design.



Fig. 4. Graffiti nature: lost, immersed, and reborn-red list.

- (5) ‘Sketch animals’ was the fifth most popular project selected by 26 participants, accounting for approximately 11.872%. Participants drew animals on paper, scan and color them, and the animals came to life in the artwork and respond to touch. It cultivated collaborative creation, expression, respect for diversity, self-efficacy, and interest in technology with innovation in the participants’ experience.



Fig. 5. Sketch animals.

- (6) ‘A Table Where Little People Live’ was the sixth most popular project selected by 19 participants, accounting for approximately 8.676%. Children moved along the screen's edges and placed objects on a table, which in turn interacted and changed the movement paths. This encouraged creativity, expressiveness, pattern recognition, logical thinking, and an understanding of physics and gravity focusing on creativity and interactivity.



Fig. 6. A table where little people live.

- (7) ‘Sliding Through the Fruit Field’ was the seventh most popular project selected by 18 participants, accounting for approximately 8.219%. Participants slid down and bumped into balls that hit seeds and flowers, helping plants grow. This cultivated ecological awareness, pattern recognition, self-verification hypothesis testing, balance, and coordination focusing on knowledge in the participant experience.

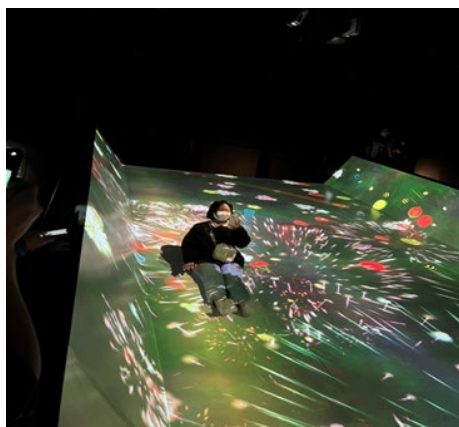


Fig. 7. Slide through the fruit field.

- (8) ‘Animals of Flowers, Symbiotic Lives II’ was the eighth most popular project selected by 14 participants, accounting for approximately 6.393%. As flowers changed and bloomed throughout the seasons, they formed animals. The image was not premade but rather created in real-time through computer programming. The image was influenced by the behavior of participants, making each viewing unique focusing on aesthetics, co-creation, and innovation.



Fig. 8. Animals of flowers, symbiotic lives.

- (9) ‘Sketch Animals Papercraft’ was the ninth most popular project selected by 11 participants, accounting for approximately 5.023%. Participants created three-dimensional paper models from painted animal pictures. This cultivated spatial awareness, understanding of different dimensions, and problem-solving skills. It focused on innovation in the participant experience.



Fig. 9. Sketch animals papercraft.

It was found that innovative interactive design applied to immersive art experiences enhanced the overall aesthetic experience. Charm and elegance, artistic and technological innovation, creativity and professionalism, trendy and cool, eye-catching and exquisite were important factors in evaluating and establishing immersive art experience designs and immersive art experiences. The collaborative creation of painting art in the National Taiwan Science Education Center in this exhibition provided opportunities for co-creation, works in the space with participants, creating different atmospheres and visual sound and light experiences for each participant. In the future, many works will be replaced by machines, making it more important to co-create with others. Comments from participants included ‘The exhibition hall was too crowded to meet the special environmental needs of participants with disabilities’. Although the exhibition unit controlled the number of participants entering, the number of participants visiting at the same time must be reduced. Qualia's design needs to be changed according to external factors such as time, environment, visual trends, and elements, rather than being fixed.

5. Conclusions

We investigated the perceived immersion and value of XR immersive art experiences in the TeamLab Planets exhibition held by the National Taiwan Science Education Center and analyzed the correlation between participants’ preferences and key factors in the immersive art experience process. The findings indicated that factors including charm and elegance, artistic and technological innovation, creativity and professionalism, trendy and cool, eye-catching, and exquisite influenced the XR immersive art experiences. Incorporating these elements in design can contribute to the current trend of immersive art experience design. Kansei engineering and Qualia design concepts were used to enhance participants' emotional and sensory satisfaction in immersive art experiences. Additionally, the concept of experience value was applied to improve participants' participation and satisfaction in the

experience. With the KJ method, we analyzed participants' feelings and images to transform them into design elements for new products such as shape, color, material, and size, to explore factors that affected participants' psychological feelings. Participants' feelings and intentions were translated into design elements that met their real needs.

The research process included determining research objectives, designing research tools, collecting data, conducting interviews and surveys, and analyzing results. Single-factor methods and statistical correction techniques were used to test reliability and validity, and principal component analysis and Varimax were used to define important factors. The survey and in-depth interviews were conducted, and the data were analyzed with factor analysis to derive an appropriate questionnaire design, recommendations, and modifications. The study result contributed to the construction of the measurement model of applying Qualia to XR extended reality experience environmental design to help relevant designers bring intuitive, surprising, metaphorical, and experiential XR extended reality experiences in terms of sustainability and design elements. The design stage of XR extended reality experience, including interesting environments and ecological experiences, becomes a popular viewing experience. Through observation and analysis of the TeamLab Planets works, we determined the sense of presence and immersion of the audience's participation and experience. The data analysis result of TeamLab Planets works revealed that the sense of presence, including the aesthetic value experience of charm and elegance and artistic and technological innovation, and the sense of immersion, the vivacious creativity and professionalism, fashion and cool virtual natural elements, and eye-catching exquisite, were the main attraction of TeamLab Planets. These factors provide new ideas and support for the development of immersive art experiences. In the future, it is necessary to explore the design application of the sense of presence and immersion in XR extended reality, achieve greater integration of art and technology, and bring more colorful aesthetic experiences to the audience.

There were limitations to overcome for future research. This study was based on 219 responses but more data may be needed for analysis. Due to venue size and clarity of projection, errors in judgment may occur when analyzing the actual textures and colors of the TeamLab Planets exhibition and transmission of music media. However, the XR design quality integrated into the exhibition creates a fashionable, avant-garde, and trendy image, which is useful for design reference.

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