

Designing for Sustainability: Exploring the Intersection of Creative Arts in Digital Sustainable Ecology by Interactive Animation

Zhao Jie^{1*}, Sanghamitra Dalal², Mohd Syuhaidi Bin Abu Bakar³, Wan Aida Wan Yahaya⁴

^{1, 2, 3, 4} College of Creative Arts, Universiti Teknologi MARA (UiTM), MALAYSIA.

¹ Tianjin Academy of Fine Arts (TAFA), CHINA.

zhaojie@tjarts.edu.cn, sanghamitra@uitm.edu.my, syuhaidi@uitm.edu.my, wanaida486@uitm.edu.my

*Corresponding author

Received: 1 November 2023, Accepted: 5 March 2024, Published: 1 April 2024

ABSTRACT

This article presents doctoral research examining the intersection of creative arts and sustainable development, focusing on interactive animation in the digital sustainable ecology. The research problem addressed is the sustainability of cultural creativity within the realm of digital media ecology, expanding the traditional understanding of ecological sustainability. The study objective aims to investigate the interplay between interactive animation, sustainable development, and digital cultural communication, exploring potential approaches for designing sustainability within interactive animation. The methodology involves drawing upon media ecology theory, conducting content analysis, and performing a comprehensive literature review and case study analysis. Findings indicate that interactive animation expresses frontage scientific concepts through artistic language, promoting cultural reflection and humanistic communication in the digital ecological environment. Interactive animation facilitates the collection of objective behavioural data, integrating scientific concepts into creative design and iterative research for sustainability. The research highlights the significance of creative arts in addressing challenges and opportunities associated with sustainable technology advancement. Exploring the intersection of creative arts and sustainable development via interactive animation, the study deepens participants' understanding of the art form which engages them in the realms of art and science. Implications include fostering cultural spectacle, promoting humanistic meditation, and integrating scientific concepts into creative design, ultimately contributing to sustainability in the digital ecological environment. Contributions involve providing insights into the potential of interactive animation as an academic research tool, expanding ecological sustainability understanding, and emphasizing the role of creative arts in advancing sustainable technology.

Keywords: *Interactive animation, digital sustainability, creative arts, media ecology, cultural spectacle.*



eISSN: 2550-214X © 2024. Published for Ideology Journal by UiTM Press. This is an Open Access article distributed under the terms of the Creative Commons Attribution-No Commercial-No Derivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

1. INTRODUCTION

The article introduces the intersection of creative arts and sustainable development, specifically focusing on interactive animation in the digital sustainable ecology. It emphasizes the importance of understanding the sustainability of cultural creativity in the digital media ecology and expands the traditional notion of ecological sustainability. The research objective is to explore the interplay between interactive animation, sustainable development, and digital cultural communication, aiming to identify approaches for designing sustainability in interactive animation. To achieve this objective, the researchers employ media ecology theory, content analysis, literature review, and case study analysis.

The findings suggest that interactive animation facilitates cultural reflection, humanistic communication, and the integration of scientific concepts into creative design for sustainability. The research highlights the significance of creative arts in addressing challenges and opportunities in sustainable technology advancement. The implications include fostering cultural spectacle, promoting humanistic meditation, and integrating scientific concepts into creative design to contribute to sustainability in the digital ecological environment. The research seeks to deepen the understanding of interactive animation as an art form and engage them in the intersection of art and science through a sustainable perspective.

1.1 Background and Significance

Feuerbach (1854, p. xi) highlighted the contemporary preference for appearances over essence and copies over originals. United Nations adopted the framework of the Sustainable Development Goals (SDGs) in September 2015, the international development agenda mentions culture for the first time (Hosagrahar, 2017, p. 12). In the context of an Internet Plus era, by exploring illusionary reality, intelligent ecosystems, interactive spectacle, and intercultural integration, the research aims to comprehend how media tech can generate cultural spectacles rooted in sustainable media tech. This aligns with the research direction of artistic and creative technology, which bridges scientific and humanistic knowledge from the two cultures (Snow & Collini, 2012, p. 60). The research seeks to explore the potential of media tech in fostering cultural integration through creative crossover. By exploring the intersection of creative arts and sustainable development in interactive animation, the study enhances participants' understanding of this art form and engages them in the realms of art and science. The implications of the research include promoting cultural spectacle, encouraging humanistic meditation, and integrating scientific concepts into creative design to contribute to sustainability within the digital ecological environment. The study also focuses on clarifying the potential of interactive animation as an academic research tool, expands understanding of ecological sustainability, and emphasizes the role of creative arts in advancing sustainable technology.

1.2 Research Problem and Objectives

This study addresses the sustainability of cultural creativity in the digital media ecology, expanding the understanding of ecological sustainability. Due to the gap between scientific and humanistic cultures, it is difficult to explore the intersection of the creative arts in cultural sustainability from the perspective of media ecology through interactive animation. The objective is to examine the interplay between interactive animation, sustainable development, and digital cultural communication, identifying approaches to incorporate sustainability into interactive animation design. The research explores the challenges of interactive animation, including its definition, creation process, and cultural values. Employing a research-creation methodology, the study analyses interactive animation from qualitative and quantitative perspectives to generate novel insights. It also investigates the impact of technological trends and constraints on creative production, examining their influence on the artistic process. Additionally, the research explores the role of cultural interpretation in artistic development, bridging the gap between art and science by analysing how cultural interpretations shape interactive animation creation and advance artistic creativity. The main objective is to explore the dynamic relationship between interactive animation, sustainable development, and digital cultural communication, discerning strategies to incorporate sustainability principles into the design of interactive animation, including its conceptualization, production process, and cultural values.

1.3 Theoretical Proposition and Methodology

While researching the influence of digitalization on sustainability to explore the Dharma of development, especially technology of media. Mao Tse-tung (2020, p. 356) argues that development tracks wave or spiral patterns rather than linear trajectories, highlighting the necessity of imbalance for the existence of balance. This research seeks to explore the applications of interactive animation in different contexts, including exploring interactive animation as an academic instrument for collecting

data. Furthermore, exploring how rooted media tech is to create emergent cultural spectacles. The research goal of 'Media-Tech Soil' is the digital sustainability of the media spectacle, which is integral to the sustainable development of media ecology, linking real and virtual ecosystems and preserving memories of past and future civilizations and using media technology and artistic creativity as a significant focus in contemporary digital media design, with interactive animation emerging as new interdisciplinary research. The methodology mainly involves drawing upon media ecology theory, qualitatively conducting content analysis with grounded theory, and performing a comprehensive literature review and case study analysis (Table 1). Mixing quantitative data analysing in research-creation by interactive questionnaire. Nystrom (1974, p. 25) aims to elucidate the goals, forms of communication interactions, questions addressed, and theoretical propositions of media ecology. Media ecology, particularly in art, analyses the relationships between artists, media, and environments using interpretative methods that combine art and technology. Media ecologists, like Innis, McLuhan, and Postman, focus on how media technologies shape social atmospheres, extending beyond the conveyance of information (Ruotsalainen & Heinonen, 2015, p. 3). Postman (2000, p. 11) suggests that 'media ecology' encompasses the dynamics between media and humanity, which influence a culture's identity and balance (Strate, 2004, p. 3). Nystrom (1974, p. 18) proposes that media ecology, as part of general systems theory, examines the relationship between communication systems, technology, and culture. It views communication as a process linking interacting elements that are more than the sum of their parts (Nystrom, 1974, p. 296). Media ecology is relevant to understanding communication and media's origins, present, and future. It asserts that studying media can contribute to understanding and transforming our world, as Wittgenstein noted, the limits of our world are tied to our media (Laskowska & Marcyński, 2019, p. 65).

Table 1: Analysis typology of Sustainability
(Source: Zhao Jie, 2023)

Type	Characteristic	Case/Example
Ecological Sustainability	Conservation and preservation of natural ecosystems.	Awaken public awareness of the footprint of plastics and carbon.
Economic Sustainability	Emphasizes the long-term viability and stability of economic systems.	Creating sustainable business digital twin by interactive animation.
Social Sustainability	Promotes social equity, inclusivity, and well-being for all individuals and communities.	Using interactive animation to address social issues and promote empathy and understanding across cultures.
Cultural Sustainability	Preserves and promotes cultural diversity and heritage.	Incorporating traditional cultural symbols and preserving cultural identity, e.g., Google Arts & Culture.
Technological Sustainability	Focuses on the responsible use and development of technology.	Exploring sustainable technologies, e.g., open-source hardware like Arduino, in interactive animation production.
Creative Sustainability	Crossover disciplines and bridge art and science with creativity.	Interactive animation blends science and art by expressing scientific concepts through sustainable creativity.

2. LITERATURE REVIEW BASED ON DIGITAL SUSTAINABILITY

2.1 Unveiling Cultural Spectacle in Digital Heritage

McLuhan once said that media is the extension of human beings (1964, p. 181). So digital sustainability can be seen as the continuation of human cultural heritage. Which is intertwined with the concept of 'spectacle', rooted in interactive media that shapes human perception through images and illusions (Buurman, 2005, p. 351; Han, 2017, p. 27). Drawing from various theoretical perspectives, the society of spectacle is associated with Marxist philosophy and critical theory (Debord, 1970, p. 16;

Frayssé, 2019, p. 11; Marx & Engels, 1887, p. 48), as well as with the changes brought by a media-oriented society and technological fetishism (Best & Kellner, 1999, p. 144). Within this context, the transmission of cultural heritage relies not only on technological sustainability but also on the preservation of the natural environment (Bovet et al., 2022, p. 102). Parikka (2012, p. 11) investigated how nineteenth-century media phenomena such as the telegraph, telephone, electricity, and light were associated with a sense of novelty and contributed to social restructuring, specialized expertise, and the integration of high-tech spectacles into daily life, which Parikka's analysis quoted the views of Marvin (1988, p. 3) in "When Old Technologies Were New." The adoption of the Sustainable Development Goals by the United Nations has highlighted the significance of safeguarding and promoting culture, emphasizing its contribution to the SDGs and the implementation of development initiatives (Abdoh, 2022, p. 2; Hosagrahar, 2017, p. 12). In the realm of digital engagement with heritage, scholars and practitioners emphasize the need for further exploration and collaboration to understand the impact of digital tools on heritage experiences (King et al., 2016, p. 76,96). Moreover, in the era of digitalization, reasonable use of digital content is crucial not only for conservation efforts but also for sustaining national identities within a globalized context (Cirulis et al., 2015, p. 199). In general, the intersection of digital sustainability, cultural heritage, and the society of spectacle necessitates ongoing research and cooperation to harness the potential of the digital world in preserving and engaging with heritage.

2.2 The Influence of Digital Technology on Sustainability

The influence of digital technology on sustainability is a complex topic that involves various pros and cons. On a positive note, the convergence of digital and multimodal cognitive technologies enables new forms of cultural interaction, facilitating the representation of thoughts, emotions, and beliefs (Bruni, 2015, p. 103). However, Bruni (2015, pp. 113, 114) cautions that technological acceleration disrupts cultural change and may lead to unpredictable and unsustainable outcomes without clear normative ideals beyond economic growth. According to Berkhout and Hertin (2004, pp. 905, 906), the environmental effects of information and communication technologies namely ICTs are considered exclusively positive due to the perception of information as separate from material resources, acting as a substitute. ICTs enhance production efficiency and enable dematerialization of various products and services, contributing to a shift towards a service economy with lower resource and energy use. However, these positive impacts must be weighed against direct impacts of electronic devices and potential behavioural changes enabled by ICTs (Berkhout & Hertin, 2004, p. 916). Schneider (2019, p. 428) asserts that highlighting the comprehensive impact of economic, social, and environmental factors aims to encourage both incumbents and startups to consider the broader consequences in shaping their digital strategies. In terms of archiving, prioritizing deliberate data selection over unlimited storage is crucial, even if it challenges digital norms (Bovet et al., 2022, p. 98). However, the establishment of physical storage centres for digital archives requires power supply and cooling systems, presenting environmental challenges (Bovet et al., 2022, p. 101). Bovet et al. (2022, p. 96) critique the ambitious aspiration of preserving everything digitally, suggesting that society's failure to prioritize ecosystem preservation undermines this dream. Sparvierio & Ragnedda pointed out blockchain, while offering potential for digital sustainability, contributes to environmental problems due to energy-intensive servers, as seen with Google's significant water consumption for data centres (2021, p. 224). The digital divide extends beyond technological access issues to encompass the limitation in skills and life opportunities, hindering global sustainability efforts (2021, pp. 223, 224). As a result, digital divide hampers digital sobriety (Bovet et al., 2022, p. 102). It is important to recognize that while digitalization may mitigate human-induced environmental impacts, it can also generate adverse environmental consequences through advanced technologies and prominent corporations (2021, p. 224).

2.3 Exploring Artistic Creativity for Sustainability

Matrahah (2019, p. 36) suggests that both arts and sciences involve a ritualistic effort to create and communicate. Concerning creating abstractions, the mind must freely wander for enhanced creativity (2019, p. 39). Watkins and Russo (2005, p. 1) propose digital cultural communication for designers to explore narrative and experience in institutions, meanwhile enabling users to become co-creation.

Coles and Pasquier (2015, p. 3) note that digital eco-artists revolutionize aesthetic and environmental engagement. The art experience shifts from contemplative to immersive. So early cave painters and contemporary digital artists develop tools to express their world experiences, paralleling the creative use of new media and digital artefacts (2015, p. 13). Creative intelligence has become a vital aspect of cultural literacy, enabling creation, connection, and inspiration. Artistic expressions and design play a significant role in culture, fostering empowerment. Culture, creativity, and artistic innovation drive development and shape our identity. In a diverse world, intercultural dialogue promotes harmony and cooperation, while technological advancements like globalization, urbanization, and AI influences creativity and sustainable development (d'Orville, 2019, pp. 65, 69, 73). Saleh and Brem (2023, p. 1) argue that creativity is an aspiration for discovering new paths to accelerate sustainability transitions. At the individual and institutional levels, creativity can enhance sustainability initiatives and solutions (2023, p. 9). Creativity on social sustainability, Skivko et al. (2021, p. 1) examine the relationship between digital culture and social habits in the context of sustainability. They argue that social sustainability involves the interplay of social values and institutions, aiming for harmony between people and the environment. Adopting sustainable social habits can enhance well-being and mitigate negative environmental impacts, promoting the aesthetic standard and creating an ideal vision (Skivko et al., 2021, pp. 2–3).

2.4 Opportunity and Challenge in Media Sustainability

In the realm of media sustainability, various scholars have explored different aspects and implications. Coles and Pasquier (2015, p. 13) draw parallels between early cave painters and the creative use of contemporary digital media tools, emphasizing the continuity of expression throughout history. Marvin (1988, p. 14) examines the cultural assumptions surrounding new forms of communication by discussing the invention of five proto-mass media in the twentieth century. Parikka (2012, p. 13) advocates for media archaeology to challenge discourses of new informational capitalism and gain a better understanding of contemporary media ecology. Bruni (2015, p. 115) introduces the concept of technological convergence and traces the historical progression of cognitive technologies. Sparviero and Ragnedda (2021, p. 217) underscore the significance of communication and culture in establishing a sustainable society and explore UNESCO's definition of digital literacy. Watkins and Russo (2005, p. 1) emphasize the interactive nature of digital technologies and their transformative impact on media literacy. Lovejoy (2004, p. 223) delves into the paradigm shift in visual representation brought about by digital media. Vervoort et al. (2014, p. 14) propose that interactive media designers and artists can contribute to societal engagement with complex social-ecological systems. However, the challenge of media sustainability also presents concerns. Mayers et al. (2015, p. 1) demonstrate by carbon footprint that large file sizes can challenge the notion that digital media distribution is always more environmentally friendly than physical distribution. Drucker (2021, p. 9) raises concerns about media storage failure and sustainability in the digital age. The occurrence of a fire incident in 2021 at an OVHCloud data centre resulted in irreversible data loss for numerous websites, exposing the vulnerability of digital systems (Bovet et al., 2022, p. 98). They discuss the challenges faced by memory institutions in transmitting cultural memories amidst technological obsolescence (2022, p. 96, 98). Moberg (2010, p. 13) expresses concerns about negative social impacts associated with sustainability, while Zayani (2011, pp. 1–2) explores the threat of cultural standardization and the preservation of diversity in a globalized context. Niankara et al. (2020, p. 14) find a negative impact of digital media consumption on adolescents' interests in the biosphere, and Gumpert and Drucker (2005, p. 381) highlight the paradoxical nature of communication technology, where increased connection can lead to insularity and control. From cave paintings to microchips, if we metaphor the 24-hour day as the story of human civilization, our most modern communication machines have all come into use within the last four seconds of our human day. (Schramm, 1988, p. 29) Media interference has been present throughout the history of human communication. Krämer (2015, p. 57) proposed "Communication: No Form without Interference." The concept of 'Idol of the Theatre' (Bacon, 2000, p. 42) has had a profound impact on people's civilized accumulation and cognitive judgment, from reality to virtuality (Le Bon, 1896, p. 56), through theatre, film, television, the Internet, and mobile phone videos. (Strate, 2018, p. 231) Media interference affects human perception subjectively, (Nusselder, 2009, p. 22) no matter

through mediate or unmediated effect(VanderWeele, 2015, p. 402). Excessive entertainment programs and dazzling commercial advertisements (Innis, 1951, p. xix; Levisky, 1999, p. 329; Sharp et al., 2019, p. 244) continuously stimulate the optic nerve and disturb people's information memory and value judgment. A phenomenon that needs to be warned in the development of sustainable digital media is that the more options we have in the media, the fewer options we can choose indeed.

3. CASE STUDY IN SUSTAINABLE MEDIA ECOLOGY

3.1 Analysis of Interactive Industry Development

The development of interactive animation in the interactive industry has been influenced by significant milestones and technical iterations. Pioneer of interactive industry, Sutherland (1963, p. 3) introduced Sketchpad, a graphical user interface with a light-pen for directly manipulating objects on the screen. Robertson et al. (1993, pp. 61, 70) conducted user studies to expand on Sutherland's thesis. Baecker (1969, pp. 2, 22) discussed using algorithms, sketches, commands, and real-time actions to create interactive computer-mediated animation with visually appealing results. Interactive animation is closely tied to AI, which began its research in the 1940s, with Turing's 1950 paper serving as a foundation, divided into three periods: early, symbolic, and natural (Millington, 2006, pp. 43–44). Computer games were ahead of their time when it came to interactive graphical interfaces, adopting them since the late 1950s, whereas non-graphical interfaces prevailed until the 1980s (Manovich, 2005, p. 7). Manovich (2005, p. 1) explores the creative energy of Generation Flash, driven using vector graphics due to limited web bandwidth, noting Flash's significant impact on web culture. Unity's tools released in 2009 shaped new gaming genres and standards for interactive animation (Foxman, 2019, p. 13), arriving just as casual gaming gained popularity and Adobe's Flash was the dominant web publishing option (Haas, 2014, p. 8). Interactive animation enables users to interact with virtual environments using smart devices like touchscreens, haptic devices, and motion sensors, interpreting the spirit of the times (Zhao, 2016, pp. 1, 203). Sustainability is a central focus in interaction design, known as Sustainable Interaction Design (SID) (Blevis, 2007, p. 503). Blevis (2007, p. 506) emphasizes integrating environmental concerns and ensuring the sustainability of induced behaviours in design methods, extending beyond environmentalism to encompass the potential effects of interactive computer games on humans. A watershed in the interaction engine industry in 2021, Adobe's discontinuation of Flash marks a significant event in interactive industry, and the new generation of interactive engines represented by Unity has become mainstream technology. Game Developer (website) analyses game engine usage on Steam, revealing Unity's dominance in mobile games and most growing popularity on PC games in engine usage rate till 2021(Doucet et al., 2021). Beside the development of the above interactive software, open-source hardware such as Arduino has also enriched the form of design in interactive industry. which engineers can utilize to custom hardware and software to solve problems across various disciplines. (Severance, 2014, p. 11).

3.2 Basing Digital Game to Promote Humanistic Meditation

The importance of ensuring game-based approaches in sustainable innovation support the transition to a more sustainable society. Serious games as tools for sustainable innovation and discuss the potential of gamification in promoting environmentally friendly behaviour (Antikainen & Bocken, 2019, pp. 376, 387) . González.G et al.(2018, p. 46) propose leveraging user personalization and emerging technologies (e.g., big data, wearables, smart technologies) to enhance engagement in game-based programs and physical exercise gamification. Utilizing serious games to promote humanistic meditation, a prototype exhibition in 2012 at NySci collaborated with Design I/O to develop an interactive installation focused on sustainability education for youth. This installation incorporated video games to explore interconnectedness and sustainability concepts across city, farm, and water environments. By emphasizing the significance of water resources, encouraging active participation, and showcasing the impact on farming, city growth, and resource conservation, it fostered a sense of responsibility for a sustainable future. In 2015, Design I/O's Connected Worlds, another immersive ecosystem at NySci, allowed users to influence the health of different environments and observe the

effects of their actions through water diversion and seed planting. By employing advanced technology such as projectors and body-tracking devices, the visually stunning and responsive simulations aimed to educate visitors about sustainability and the interdependence of ecosystems. This unique installation provided children with immediate feedback and the opportunity to engage with nature through technology (National Endowment for the Arts, 2021, p. 89). Antle et al. (2011, p. 195) designed Futura, a collaborative learning game, to engage the public in understanding sustainability issues. The game explores the complex trade-offs and stakeholder views involved in urban planning for a sustainable future. By working together, players aim to support population growth while minimizing environmental impact. Losing the game also promotes learning by highlighting the challenges of sustainable development. Field study findings indicate that this fast-paced, role-based simulation effectively educates the public about sustainability complexities (2011, pp. 194–209). AGCS Works and Plastic Soup Foundation launched a DOOH game at Westfield London, emphasizing the need to reduce ocean plastic waste. The game, a winner in Ocean's 2019 Digital Creative Competition, engages players through interactive gameplay and promotes an app for minimizing plastic consumption. Academia proposed the plastic footprint concept (Boucher et al., 2020, p. 9; Klemeš et al., 2021, p. 1), while the AGCS Works and Plastic Soup Foundation utilized gamification in a DOOH game at Westfield London to raise awareness about reducing ocean plastic waste. The game, titled 'My Little Plastic Footprint', won the Ocean's 2019 Digital Creative Competition and encourages players to minimize plastic consumption through interactive gameplay and an associated app. Operated by the Plastic Soup Foundation and supported by the UN, this application aims to engage the public in pro-environmental behaviours and combat ocean pollution (Ouariachi et al., 2020, p. 7).

3.3 Design Simulations for Sustainable Ecology

The aim of this academic endeavour is to develop simulations using a case analysis approach to explore the applications of key concepts, Data visualization, Digital Twin and AI for good, etc., with the specific goal of promoting sustainable ecology. Professor Teo utilizes 3D maps to visualize population density patterns in six countries, highlighting the uneven distribution of population within countries in 2022. The maps, created using open-source data and programming tools, reveal concentration and dispersion trends. France exhibits a high population concentration in Paris, while Germany has multiple dense cities. Italy experiences population spikes along its coastline, and Chile's population centres are concentrated around its capital. Turkey's urban growth is influenced by mountains and diverse climates, while Canada's major urban centres are found along the St. Lawrence River. The study emphasizes the importance of mapping and studying urban development for sustainable urban planning and understanding political and economic power dynamics (Teo, 2023). Taylor, in the data visualization project 'Transit in Motion', employed animation and 3D design to animate location data, focusing on the COVID-19 pandemic's impact on public transport and flight traffic. Through GPS-enabled data, various cities' activity levels and patterns were visualized, emphasizing organic beat and mobility patterns using abstract visualizations like pillar-based designs and voxel grids. This work is described as data art, prioritizing creating exhibits or artefacts through data rather than sharing insights. Taylor's video 'Transit in Motion' captures this approach, released in June 2020 (Kirk, 2021, pp. 2–3, 6). Shan He (2020, p. 88) emphasized the significance and difficulties of data visualization, demonstrating its potential in revealing patterns and anomalies in large datasets. She highlighted the iterative nature of creating effective visualizations and introduced Kepler GL as a user-friendly tool for exploring and creating maps. With a focus on accessibility, Shan stressed the need for powerful visualization tools and invited attendees to explore career opportunities at Uber, recognizing her role as the founder of Uber's data visualization team and the creator of kepler.gl software. Allam et al. (2022, p. 3) explores the connections between the '15-Minute City' and 6G, IoT, and Digital Twins technologies. Carlos Moreno introduced the '15-Minute City' in 2016, emphasizing the importance of people-centric urban planning. The case aims to establish a framework for urban efficiency, resilience, and sustainability by analysing the interplay between these technologies and the paradigm of sustainable smart city (2022, p. 3). C. Schneider & Betz (2022, p. 5) highlight the cultural link between digitalization and sustainability through the example of the 'AI for Good' conferences

organized by the UN with involvement from the Xprize Foundation. The collaboration between these actors reflects dominant visions of sustainability and disruptive.

3.4 Preserving Cultural Heritage through Digital Sustainability

Statham (2019, pp. 2–10) conducts a heuristic evaluation of the commonly used online platforms, namely Google Arts & Culture, CyArk, 3DHOP, Sketchfab, and game engines, to assess their alignment with ICOMOS and UNESCO guidelines on heritage management and their capacity to provide scientific context to 3D visualizations of cultural heritage. The author highlights game engines as a favourable option due to their flexibility, especially for large projects with sufficient funding, as they offer long-term sustainability and lower maintenance costs compared to online platforms. Abdurrahman (2018, p. 3) contends that globalization and appropriation drive the transformation of exclusive elements and knowledge from specific social groups into novel cultural entities, regardless of their original time and space. Scopigno et al. (2017, p. 1) acknowledge the maturity of digital technologies in producing high-quality digital replicas of cultural heritage assets but emphasize the need to effectively deliver and disseminate these data and related knowledge to society. They observe that web-publishing solutions for 3D data are becoming a de facto standard for various applications. Furthermore, Statham (2019, p. 6) describes Google Arts & Culture as a platform allowing museums and cultural institutions to share collections and projects through traditional webpage formats, albeit lacking interactive 3D support. In addition, Google Arts & Culture Lab introduces 'Viola the Bird', an interactive cultural game that combines music and technology to facilitate musical exploration and creativity. The transformative potential of generative AI is also noted, particularly in the video game industry, where startups utilize AI to create lifelike non-player characters (NPCs) and immersive experiences. GAEA technology from Parametrix.ai, enables the development of autonomous NPCs with diverse personalities and realistic behaviours, enhancing player engagement and offering opportunities for a personalized content generation 'Living Chang'an City' for preserving cultural heritage through digital preservation. These advancements have garnered significant interest within the gaming community, showcasing the potential for preserving cultural heritage through digital means.

3.5 Fostering Cultural Spectacle by Virtual Art Exhibition

According to Amir et al. (2022, p. 7), the virtual realm has become an integral aspect of contemporary reality, with increasing acknowledgement of its practicality. Motaianu.M and Motaianu.C (2021, pp. 488–489) demonstrate the efficacy of the Artivive, an AR application, which utilizes recognition-based technology, in enabling the visualization of augmented reality art. This tool allows artists to seamlessly combine traditional and digital art, providing a novel artistic dimension and unlocking a world of creative possibilities. By incorporating a digital layer, artists can offer visitors an enhanced emotional experience, taking them on a journey through time, explaining the artwork's background, and conveying narratives. Two notable exhibitions, 'Sustainable Singapore' and 'Visualizing Bias with Augmented Reality', showcased the diverse visions and interpretations of artists, designers, and the public, emphasizing the transformative impact of technology on our perception of reality. Wagner and Kabalska (2023, p. 1652) demonstrate how the development of digital twins (DTs) in the fashion industry alters value chains and addresses sustainability needs. They examine creating sustainable value through physical and virtual processes via DTs. Ahn et al. (2023, p. 1) analyse the impact of user interaction on the user experience (UX) in virtual reality (VR) fashion shows, exploring interaction elements and the production process, e.g., Global Talents Digital combines real and digital collections globally, beyond traditional fashion seasons, contributing to the vibrant fashion scene. Fostering cultural spectacle through virtual art exhibitions involves the utilization of machine intelligence, algorithms, and vast data sets. Refik Anadol, a new media artist and designer, considers data as a pigment and employs algorithms as brushes to render intricate artworks. By employing machine learning algorithms, Anadol transforms extensive image collections and data into dynamic visualizations and sculptures, thereby making hidden connections and dynamic processes visible. Through his projects, Anadol explores the interplay between humans and machines, utilizing data as a medium for imagination that transcends traditional artistic boundaries, fostering new connections and

meanings. Ultimately, his work highlights the potential of artificial intelligence to either foster communities or incite destruction, prompting contemplation on the complex relationship between humans, technology, and artistic expression (National Endowment for the Arts, 2021, pp. 23, 87). Virtual art exhibitions with the integration of technology in art and fashion have the capacity to foster cultural spectacles, offering new possibilities for artistic expression, sustainable value creation, and immersive experiences that blend art, technology, and human perception.

4. RESEARCH CREATION BY INTERACTIVE ANIMATION

4.1 Contemporary Narrative from Traditional Cultural Symbols

According to Rebutisch (2015, p. 223), contemporary art is often seen as neutral and reflective of the present moment, distancing itself from the anti-conformist and progressive nature of modern art. Contemporary art is viewed as an ongoing and self-transforming modernity (Rebutisch, 2015, p. 237). This study explores the creative and cultural implications of contemporary interactive animation in the era of Internet Plus, focusing on media spectacle, crossover integration, and artistic creation as a means of cultural meditation. The aim is to bridge the language of art and science, investigating the role of cultural interpretation in artistic development. Traditional animation is rooted in film art (Crafton, 2011, p. 105), while interactive animation uses computer technology to represent and express fantasies and illusions, enabling interactions between humans and machine (Seifert, 2008, p. 10; Zhao, 2016, p. 15). It allows users to interact with virtual environments using smart devices. Interactive animation can facilitate engagement with cultural heritage and traditional arts and culture (Liang et al., 2016, p. 7). Major media spectacles encapsulate the significant concerns of the era, attracting the interest of contemporary audiences (Kellner, 2003, p. 28). Li (2020, pp. vii–viii) explores a new interactive aesthetic of data visualization that combines traditional Chinese aesthetics with gesture-based gaming technology, transforming the human body's relationship with technology. Understanding the artistic expression of interactive animation reveals its potential for creating immersive experiences and connecting traditional aesthetics and modern digital technology (Chow & Harrell, 2012, p. 50; Li, 2020, p. 48). Semiotics is applied to analyse the symbol system and meaning in interactive animation art. Traditional Cultural Symbols, e.g., Son Goku in Dragon Ball Manga, which rebuilt from a popular myth 'Journey to the west', is believed to be a collection of texts from diverse cultural civilizations scattered across the earth, involving elements and knowledge from various spaces and past times (Abdurrahman, 2018, p. 3). In 2016, the pre-research of the project tried to carry out the interactive animation art creation 'Journey to the Modern' (<http://www.balancerstudio.cc>). The research aims to understand the theoretical and cultural significance of interactive animation art language through analysis, case studies, and artistic creation, fostering diversification and meaningful interaction. The goal is to create engaging and entertaining experiences for viewers while exploring digital sustainability of media spectacle and fostering cultural mediation between different cultures (Lelièvre, 2018, p. 2).

4.2 Integrating Scientific Concepts into Creative Design

The artistic theory and creative practice of interactive animation is the historic mission of the creators of experimental media by integrating scientific concepts into creative sustainability. Scientific and humanistic knowledge in the two cultures (Snow & Collini, 2012, p. 60), which reflect the research direction of Artistic and Creative Technology. The goal of this research is to explore the potential of media-tech to create cultural integration through creative crossover. According to Guilford (1950, p. 444), Lai (2011, p. 76), and Sternberg & Lubart (1999, p. 3), creativity is a characteristic capacity of creative individuals, influenced by motivational and temperamental traits. In a broader sense, as discussed by Candy & Edmonds (2002, p. 141), Coler (1968, p. 256), Fischer & Vassen (2011, pp. 205, 214), and Mumford (2012, p. 11), creativity manifests through invention within teams or societies. While individual creativity has been traditionally emphasized, creative and innovative work often occurs in group settings, where interactive features can either promote or inhibit creativity and innovation. This interactive animation research integrates scientific and technological innovation with the humanities and arts, exploring the concept of 'The Quantum Art Gallery' from a media ecology

perspective to design an interactive questionnaire (Figure 1). Quantum art combines art and science, interpreting phenomena through quantum physics concepts. The practice aims to visualize interactions, randomness, interference, superposition, and emergence, constructing a new paradigm for cultural and artistic creation. By utilizing online interactive animation, it collects first-hand data for analysis while investigating the constraints and facilitations posed by media technology. The research adopts an interpretive paradigm, emphasizing subjective understanding of individuals' cultural and social context, experiences, motivations, and artistic processes in 3D interactive animation art. Boden (2005, pp. 1–2) discusses how interactive artworks can incorporate unpredictability and the repeated denial of expectations. Creativity, viewed as both fascinating and mysterious, poses a challenge for scientific understanding due to its inherently unpredictable nature (Boden, 2004, pp. 13, 233, 254).

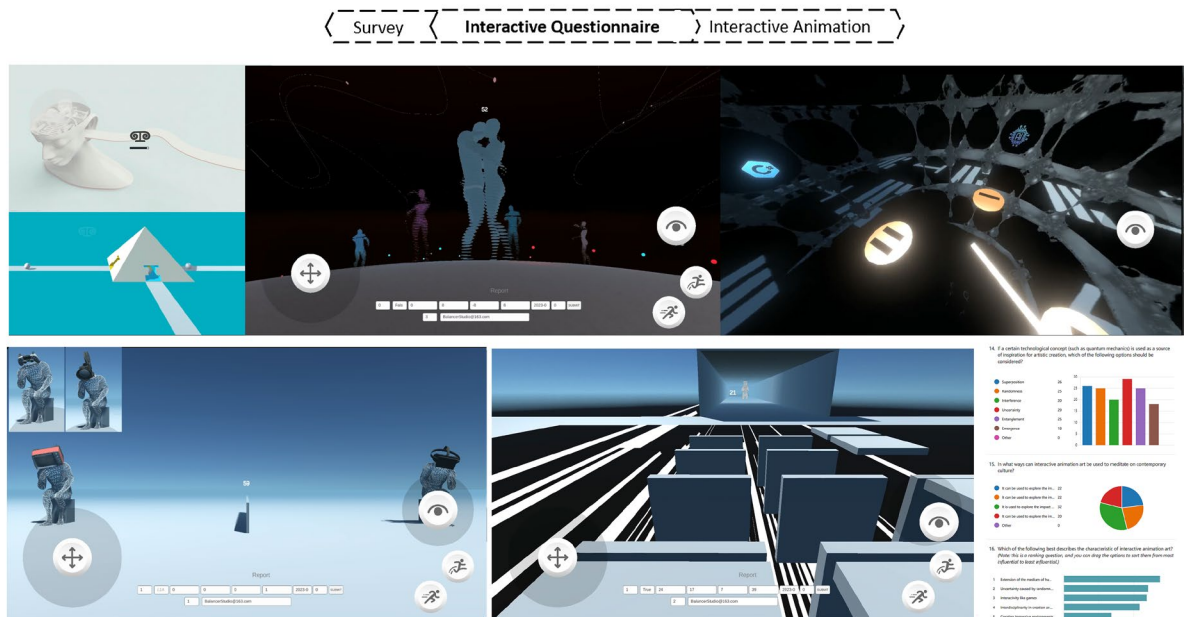


Figure 1 Interactive Questionnaire 'The Quantum Art Gallery'
(Source: Zhao Jie, 2023, Copyright Consent: Permissible to Publish)

4.3 Interactive Instrument for Collecting Academic Data

Interactive animation is explored as an academic instrument for data collection. Aesthetic Interaction holds intrinsic and instrumental value, offering a rewarding and dynamic form different from traditional design (Hallnas, 2011, p. 4). Hallnas suggests connecting interaction to design aesthetics as a foundation, rather than behavioural and social science (2011, p. 73). Interactive design focuses on the expressiveness of use, while aesthetics encompasses both the expressiveness of design and usage (2011, p. 74). Users assign values to interactive possibilities to reduce design uncertainty, aided by interaction aesthetics (Xenakis & Arnellos, 2013, p. 14). The research proposal utilizes Unity 3D online interactive animations as the primary instrument for data collection, requiring the development of interactive elements and various technologies. Testing processes such as topology evaluation, 3D rendering quality assessment, playability testing, and accessibility testing will be conducted. The research design will be supplemented by quantitative analysis using MySQL for data collection. The research process of 'The Quantum Art Gallery' involves conducting relevant research, identifying challenges, gathering data and feedback, and analysing questionnaires. The testing process includes topology evaluation, 3D rendering quality assessment, playability testing, functionality testing, compatibility testing, and accessibility testing. The research aims to explore the potential applications of interactive animation in the digital age, promote cultural integration, and investigate the use of media-tech for cultural mediation and emergent cultural spectacles. The preliminary conclusion suggests that people are more inclined to choose interaction scenarios characterized by uncertainty, interference, and randomness based on the data analysis of A/B testing. In this testing of the interactive questionnaire

with a small sample of 30 people in the early stage of the study (Figure 2), the length of stay and the number of choices showed a positive correlation distribution.

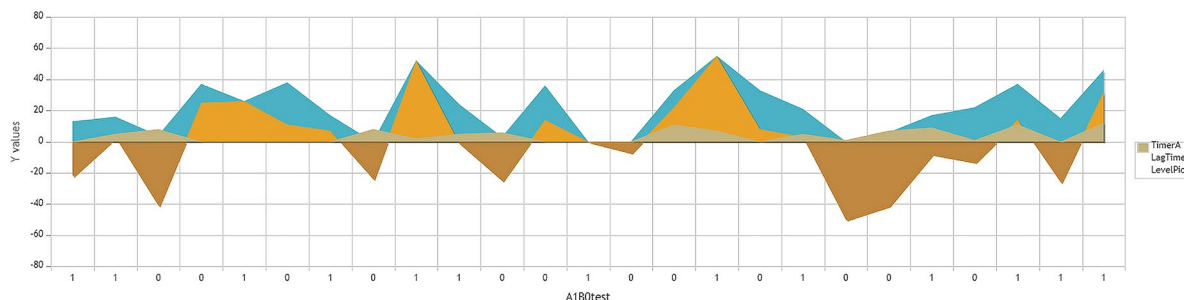


Figure 2 Flot Area Chart of A/B Testing in Interactive Questionnaire
(Source: Zhao Jie, 2023, Copyright Consent: Permissible to Publish)

5. FINDINGS AND CONCLUSION

5.1 Achieving Ecological Sustainability in the Digital Beings

This research investigates the interplay between interactive animation, sustainable development, and digital cultural communication within the digital sustainable ecology. By utilizing media ecology theory and employing methodologies such as content analysis, literature review, and case study analysis, the study explores how interactive animation effectively expresses scientific concepts through artistic language, fostering cultural reflection and humanistic communication in the digital environment. It also highlights the importance of creative arts in addressing challenges and opportunities related to sustainable technology advancement. Through the exploration of interactive animation's potential for sustainability, the research enhances participants' understanding and engagement in the realms of art and science. It emphasizes the significance of integrating scientific concepts into creative design and recognizes interactive animation as a valuable academic research tool that expands our understanding of ecological sustainability and promotes the role of creative arts in advancing sustainable technology. Heidegger (2007, p. 113) argues that a mere interpretation of fetishism and magic based on signs is insufficient to understand the "Being-ready-to-hand" inherent in entities encountered in the primitive world. Negroponte (1995, p. 78) suggests that interaction is implicit in all forms of multimedia in digital beings. By utilizing interactive questionnaires, this research enables the collection of more objective behavioural data on subconsciously biased choices, providing accurate and objective insights into the artistic language of interactive animation while gathering valuable survey data for a comprehensive exploration of ecological sustainability in the digital realm.

5.2 Recommendations for Future Research

Future research should explore interactive art, especially interactive animation, to strengthen the study of the protection, inheritance, and dissemination of sustainable development in culture. This can be achieved by involving viewers in sustainable development research and cultural communication through interactive animation, enabling the conveyance of artistic value and effective feedback. Such endeavours hold significant importance for the sustainable communication of the culture and the future development of media ecology. Additionally, researchers should continue to investigate the intersection of creative arts and digital sustainable ecology, focusing on interactive animation. This interdisciplinary research can contribute to understanding the role of media in shaping our world and explore new avenues for media design that integrate media technology, artistic creativity, and interactive aesthetics. Subsequent research and achievements will continue in my doctoral research proposal 'Media Spectacle & Crossover Integration: Artistic Creation and Cultural Meditation in Contemporary Interactive Animation'. Moreover, future research should explore how cultural studies and interactive aesthetics can stimulate artistic thinking in multimedia design, examine the emotional and affective aspects of interactive design, analyse the aesthetic positions in different definitions of games, and investigate how

interaction systems facilitate creative activity. Furthermore, research efforts should investigate how interactive animation can facilitate engagement with cultural heritage and foster an appreciation of traditional arts and culture among younger generations. Finally, future studies should explore the relationship between interaction aesthetics, aesthetic experience, and human activities and conditions of life, and further develop frameworks that integrate communication, embodied interactive aesthetic perception, traditional aesthetics, and classical philosophy to enhance understanding of data visualization.

ACKNOWLEDGMENT

I extend my heartfelt appreciation to the editors, commentators, and participants of this volume, including the symposium on POSDEV2023, for their valuable feedback and lively discussions. I am grateful to my supervisors, Dr. Sanghamitra Dalal and Prof. Dr. Mohd Syuhaidi, for their instrumental assistance and insights. Special thanks to my family for their unwavering support, granting me the necessary time for scientific research. Their backing serves as a strong foundation both spiritually and materially. I express my sincere gratitude to all mentioned individuals for their contributions to the successful completion of this research project.

FUNDING

Tianjin Academy of Fine Arts, 2021 college scientific research project 'Interaction & interference: Humanistic meditation on interactive spectacle and interfering medium in the digital beings' (Project No. 202118)

AUTHOR CONTRIBUTIONS

Sanghamitra Dalal, as the main supervisor, provided guidance in interdisciplinary research and academic writing. Mohd Syuhaidi, as the co-supervisor, instructed in Research Methodology and Media Theory. Their contributions were instrumental in shaping the content and methodology of this publication, ensuring its academic rigor and comprehensiveness.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest with any individuals or organizations that could potentially influence the findings, or the interpretation of the results presented in this publication.

REFERENCES

- Abdoh, S. A. (2022). Art and sustainability: Can digital technologies achieve sustainability? *Journal of Cultural Heritage Management and Sustainable Development, ahead-of-print*(ahead-of-print). doi: 10.1108/JCHMSD-03-2022-0038
- Abdurrahman, D. I. (2018). Transcultural Appropriation on the Son Goku Character Configuration from Dragon Ball Manga. *Ideology Journal, 3*(2), 3–10. doi: 10.24191/idealogy.v3i2.52
- Ahn, D.-K., Bae, B.-C., & Kim, Y. (2023). User Experience of a Digital Fashion Show: Exploring the Effectiveness of Interactivity in Virtual Reality. *Applied Sciences, 13*(4), Article 4. doi: 10.3390/app13042558
- Allam, Z., Bibri, S. E., Jones, D. S., Chabaud, D., & Moreno, C. (2022). Unpacking the '15-Minute City' via 6G, IoT, and Digital Twins: Towards a New Narrative for Increasing Urban Efficiency, Resilience, and Sustainability. *Sensors, 22*(4), Article 4. doi: 10.3390/s22041369
- Amir, N. M. A. H., Mazlan, H., & Omar, A. (2022). Virtual Art Gallery Tour: Understanding The Curatorial Approach. *Ideology Journal, 7*(2), Article 2. doi: 10.24191/idealogy.v7i2.349
- Antikainen, M., & Bocken, N. (2019). Game-Based Approaches to Sustainable Innovation. In P. Ritala, L. Albareda, R. Verburg, & Nancy Bocken (Eds.), *Innovation for Sustainability: Business*

- Transformations Towards a Better World* (pp. 375–392). Cham: Springer International Publishing. doi: 10.1007/978-3-319-97385-2_20
- Antle, A. N., Tanenbaum, T. J., Bevans, A., Seaborn, K., & Wang, S. (2011). Balancing Act: Enabling Public Engagement with Sustainability Issues through a Multi-touch Tabletop Collaborative Game. In P. Campos, N. Graham, J. Jorge, N. Nunes, P. Palanque, & M. Winckler (Eds.), *Human-Computer Interaction – INTERACT 2011* (pp. 194–211). Springer. doi: 10.1007/978-3-642-23771-3_16
- Bacon, F. (2000). *The new organon* (L. Jardine & M. Silverthorne, Eds.). Cambridge [U.K.]; New York: Cambridge University Press.
- Baecker, R. M. (1969). *Interactive Computer-mediated Animation* [MASSACHUSETTS INST OF TECH CAMBRIDGE PROJECT MAC]. <http://publications.csail.mit.edu/lcs/pubs/pdf/MIT-LCS-TR-061.pdf>
- Berkhout, F., & Hertin, J. (2004). De-materialising and re-materialising: Digital technologies and the environment. *Futures*, 36(8), 903–920. doi: 10.1016/j.futures.2004.01.003
- Best, S., & Kellner, D. (1999). Debord, Cybersituations, and the Interactive Spectacle. *SubStance*, 28(3), 129–156. doi: 10.1353/sub.2006.0002
- Blevis, E. (2007). Sustainable interaction design: Invention & disposal, renewal & reuse. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 503–512. doi: 10.1145/1240624.1240705
- Boden, M. A. (2004). *The creative mind: Myths and mechanisms* (2nd ed). London: Routledge.
- Boden, M. A. (2005). Aesthetics and interactive art. *Proceedings of the 5th Conference on Creativity & Cognition*, 1–2. doi: 10.1145/1056224.1056225
- Boucher, J., Billard, G., Simeone, E., & Sousa, J. (2020). *The marine plastic footprint*. IUCN, International Union for Conservation of Nature. doi: 10.2305/IUCN.CH.2020.01.en
- Bovet, D., Jambé, A., & Michel, P. M. (2022). *(Im)possible History? Digital Ecology as an Approach to Transmit Memory and Cultural Heritage*. 94–105. doi: 10.11588/dco.2022.8.89027
- Bruni, L. E. (2015). Sustainability, cognitive technologies and the digital semiosphere. *International Journal of Cultural Studies*, 18(1), 103–117. doi: 10.1177/1367877914528121
- Buurman, G. M. (2005). *Total interaction: Theory and practice of a new paradigm for the design disciplines*. Basel ; [Great Britain]: Birkhäuser.
- Candy, L., & Edmonds, E. (2002). Modeling co-creativity in art and technology. *Proceedings of the Fourth Conference on Creativity & Cognition - C&C '02*, 134–141. doi: 10.1145/581710.581731
- Chow, K. K. N., & Harrell, D. F. (2012). Understanding Material-Based Imagination: Cognitive Coupling of Animation and User Action in Interactive Digital Artworks. *Leonardo Electronic Almanac*, 17(2), 50–64. doi: 10.5900/SU_9781906897161_2012.17(2)_50
- Cirulis, A., Paolis, L. T. D., & Tutberidze, M. (2015). Virtualization of Digitalized Cultural Heritage and Use Case Scenario Modeling for Sustainability Promotion of National Identity. *Procedia Computer Science*, 77, 199–206. doi: 10.1016/j.procs.2015.12.384
- Coler, M. A. (1968). Creativity in Technology and the Arts. *Leonardo*, 1(3), 265. doi: 10.2307/1571870
- Coles, L. L., & Pasquier, P. (2015). Digital eco-art: Transformative possibilities. *Digital Creativity*, 26(1), 3–15. doi: 10.1080/14626268.2015.998683
- Crafton, D. (2011). The Veiled Genealogies of Animation and Cinema. *Animation*, 6(2), 93–110. doi: 10.1177/1746847711404979
- d’Orville, H. (2019). The Relationship between Sustainability and Creativity. *Cadmus*, 4(1), 65–73.
- Debord, G. (1970). *The Society of the Spectacle* (F. Perlman, Trans.). Black & Red. <https://library.brown.edu/pdfs/1124975246668078.pdf>
- Doucet, L., September 02, A. P., & 2021. (2021, September 2). *Game engines on Steam: The definitive breakdown*. Game Developer. <https://www.gamedeveloper.com/business/game-engines-on-steam-the-definitive-breakdown>
- Drucker, J. (2021). Sustainability and complexity: Knowledge and authority in the digital humanities. *Digital Scholarship in the Humanities*, 36(Supplement_2), ii86–ii94. doi: 10.1093/lhc/fqab025
- Feuerbach, L. (1854). *The essence of Christianity* (G. Eliot, Trans.). London: John Chapman. <http://archive.org/details/a581696600feneuoft>
- Fischer, G., & Vassen, F. (Eds.). (2011). *Collective Creativity: Collaborative Work in the Sciences, Literature and the Arts*. BRILL. doi: 10.1163/9789042032743

- Foxman, M. (2019). United We Stand: Platforms, Tools and Innovation With the Unity Game Engine. *Social Media + Society*, 5(4), 205630511988017. doi: 10.1177/2056305119880177
- Frayssé, O. (2019). Gazing at “Fetishes” 2.0: Using the Spectacle Concept to Understand Consumer Cultures in the Age of Digital Capitalism. *InMedia*, 7.2. doi: 10.4000/inmedia.1902
- González González, C. S., Gómez del Río, N., & Navarro Adelantado, V. (2018). Exploring the Benefits of Using Gamification and Videogames for Physical Exercise: A Review of State of Art. *IJIMAI*, 5(2), 46–52.
- Guilford, J. P. (1950). Creativity. *American Psychologist*, 5(9), 444–454. doi: 10.1037/h0063487
- Gumpert, G., & Drucker, S. (2005). The Perfections of Sustainability and Imperfections in the Digital Community: Paradoxes of Connection and Disconnection. In P. van den Besselaar & S. Koizumi (Eds.), *Digital Cities III. Information Technologies for Social Capital: Cross-cultural Perspectives* (pp. 369–379). Springer. doi: 10.1007/11407546_22
- Haas, J. K. (2014). *A History of the Unity Game Engine*. <https://www.semanticscholar.org/paper/A-History-of-the-Unity-Game-Engine-Haas/5e6b2255d5b7565d11e71e980b1ca141aeb3391d>
- Hallnas, L. (2011). On the Foundations of Interaction Design Aesthetics: Revisiting the Notions of Form and Expression. *International Journal of Design*, 5(1), 73–84.
- Han, B.-C. (2017). *In the swarm: Digital prospects*. Cambridge, MA: MIT Press.
- He, S. (2020). Data-Driven Urbanism: The Balance Between Spatial Intelligence and Design Craftsmanship. *Architectural Design*, 90(3), 86–93. doi: 10.1002/ad.2573
- Heidegger, M. (2007). *Being and time* (J. Macquarrie & E. Robinson, Trans.). Malden (Mass.): Blackwell publ.
- Hosagrahar, J. (2017). Culture: At the Heart of the SDGs. *The UNESCO Courier*, vol.1, 12–14.
- Innis, H. A. (1951). *The bias of communication* (1st ed.). Toronto: Univ. of Toronto Press.
- Kellner, D. (2003). Media Spectacle. In *Routledge*. Routledge. doi: 10.4324/9780203166383
- King, L., Stark, J. F., & Cooke, P. (2016). Experiencing the Digital World: The Cultural Value of Digital Engagement with Heritage. *Heritage & Society*, 9(1), 76–101. doi: 10.1080/2159032X.2016.1246156
- Kirk, A. (2021). Visualization Insights From Craig Taylor’s “Transit in Motion.” *Sage Research Methods: Data Visualization*. doi: 10.4135/9781529779301
- Klemeš, J. J., Fan, Y. V., & Jiang, P. (2021). Plastics: Friends or foes? The circularity and plastic waste footprint. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 43(13), 1549–1565. doi: 10.1080/15567036.2020.1801906
- Krämer, S. (2015). *Medium, messenger, transmission: An approach to media philosophy* (A. Enns, Trans.). Amsterdam: Amsterdam University Press.
- Lai S. (2011). *Stan Lai on Creativity*. Guilin: Guangxi Normal University Press.
- Laskowska, M., & Marcyński, K. (2019). Media Ecology – (Un)necessary Research Perspective in Communication and Media Studies. *Mediatization Studies*, 3, 53. doi: 10.17951/ms.2019.3.53-68
- Le Bon, G. (1896). *The Crowd: A Study of the Popular Mind*. NEW YORK: THE MACMILLAN CO.
- Lelièvre, E. (2018). Research-creation methodology for game research. *Hal.Science*. <https://hal.science/hal-02615671>
- Levisky, D. L. (1999). The media: Interference with the psyche. *International Journal of Adolescent Medicine and Health*, 11(3–4), 327–333. doi: 10.1515/IJAMH.1999.11.3-4.327
- Li, Q. (2020). *Embodying Data: Chinese Aesthetics, Interactive Visualization and Gaming Technologies*. Singapore: Springer Singapore. doi: 10.1007/978-981-15-5069-0
- Liang, H., Deng, S., Chang, J., Zhang, J. J., Chen, C., & Tong, R. (2016). *Ontology-based interactive animation/game generation for Chinese shadow play preservation*. 9. doi: 10.1109/vs-games.2016.7590354
- Lovejoy, M. (2004). *Digital Currents: Art in the Electronic Age* (0 ed.). Routledge. doi: 10.4324/9780203005279
- Manovich, L. (2005). Generation Flash. In G. M. Buurman (Ed.), *Total Interaction* (pp. 67–77). Basel: Birkhäuser-Verlag. doi: 10.1007/3-7643-7677-5_6
- Mao Tse-tung. (2020). *Selected Works of Mao Tse-tung, Volume VIII* (2nd ed., Vol. 2). Paris: Foreign Languages Press. <https://flpress.storenvy.com/products/31038724-selected-works-of-mao-tse-tung-volume-viii>

- Marvin, C. (1988). *When old technologies were new: Thinking about electric communication in the late nineteenth century*. New York: Oxford University Press.
- Marx, K., & Engels, F. (1887). *Capital: A critique of political economy. Volume 1, The process of production capital Volume 1, The process of production capital* (S. Moore & E. B. Aveling, Trans.). Moscow: Progress Publishers.
<https://www.marxists.org/archive/marx/works/download/pdf/Capital-Volume-I.pdf>
- Matrahah, I. (2019). Commentary: The moment of truth - transcending knowledge through myriads of creativity. *Ideology Journal*, 4(2), Article 2.
- Mayers, K., Koomey, J., Hall, R., Bauer, M., France, C., & Webb, A. (2015). The Carbon Footprint of Games Distribution. *Journal of Industrial Ecology*, 19(3), 402–415. doi: 10.1111/jiec.12181
- McLuhan, H. M. (1964). *Understanding media: The extensions of man*. New York: New American Library. <http://archive.org/details/understandingmed00mclurich>
- Millington, I. (2006). *Artificial intelligence for games*. Amsterdam; Boston: Morgan Kaufmann: Elsevier.
- Moberg, Å. (2010). *Assessment of media and communication from a sustainability perspective*. <https://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-12502>
- Motaianu, M., & Motaianu, C. (2021). Signs and Emotions as the Experience of the Urban Explorer. *LUMEN Proceedings*, 17, 482–491. doi: 10.18662/wlc2021/48
- Mumford, M. D. (Ed.). (2012). *Handbook of organizational creativity* (1st ed). Amsterdam; Boston: Elsevier/Academic Press.
- National Endowment for the Arts. (2021). *Tech as Art: Supporting Artists Who Use Technology as a Creative Medium* (p. 126). Washington: National Endowment for the Arts. <https://www.arts.gov/impact/research/publications/tech-art-supporting-artists-who-use-technology-creative-medium>
- Negroponte, N. (1995). *Being digital* (1. publ). London: Hodder & Stoughton.
- Niankara, I., Noor Al adwan, M., & Niankara, A. (2020). The Role of Digital Media in Shaping Youth Planetary Health Interests in the Global Economy. *Journal of Open Innovation: Technology, Market, and Complexity*, 6(3), 49. doi: 10.3390/joitmc6030049
- Nusselder, A. (2009). *Interface fantasy: A Lacanian cyborg ontology*. Cambridge, Mass: MIT Press.
- Nystrom, C. L. (1974). *Toward a Science of Media Ecology: The Formulation of Integrated Conceptual Paradigms for the Study of Human Communication Systems*. [Ph.D., New York University]. <https://www.proquest.com/docview/287996744/citation/F50F7B23A4244BB1PQ/1>
- Ouariachi, T., Li, C.-Y., & Elving, W. J. L. (2020). Gamification Approaches for Education and Engagement on Pro-Environmental Behaviors: Searching for Best Practices. *Sustainability*, 12(11), Article 11. doi: 10.3390/su12114565
- Parikka, J. (2012). *What is media archaeology?* Cambridge, UK; Malden, MA: Polity Press.
- Postman, N. (2000). The Humanism of Media Ecology. *Proceedings of the Media Ecology Association*, 1(1), 10–16.
- Rebentisch, J. (2015). The Contemporaneity of Contemporary Art. *New German Critique*, 42(1), 223–237. doi: 10.1215/0094033X-2753672
- Robertson, G. G., Card, S. K., & Mackinlay, J. D. (1993). Information visualization using 3D interactive animation. *Communications of the ACM*, 36(4), 57–71. doi: 10.1145/255950.153577
- Ruotsalainen, J., & Heinonen, S. (2015). Media ecology and the future ecosystemic society. *European Journal of Futures Research*, 3(1), 9. doi: 10.1007/s40309-015-0068-7
- Saleh, R., & Brem, A. (2023). Creativity for sustainability: An integrative literature review. *Journal of Cleaner Production*, 388, 135848. doi: 10.1016/j.jclepro.2023.135848
- Schneider, C., & Betz, S. (2022). Transformation²: Making software engineering accountable for sustainability. *Journal of Responsible Technology*, 10, 100027. doi: 10.1016/j.jrt.2022.100027
- Schneider, S. (2019). The Impacts of Digital Technologies on Innovating for Sustainability. In N. Bocken, P. Ritala, L. Albareda, & R. Verburg (Eds.), *Innovation for Sustainability: Business Transformations Towards a Better World* (pp. 415–433). Cham: Springer International Publishing. doi: 10.1007/978-3-319-97385-2
- Schramm, W. (1988). *The story of human communication: Cave painting to microchip*. New York: Harper & Row.

- Scopigno, R., Callieri, M., Dellepiane, M., Ponchio, F., & Potenziani, M. (2017). Delivering and using 3D models on the web: Are we ready? *Virtual Archaeology Review*, 8(17), Article 17. doi: 10.4995/var.2017.6405
- Seifert, U. (2008). Paradoxes of interactivity: Perspectives for media theory, human-computer interaction, and artistic investigations. In *The Co-Evolution of Humans and Machines: A Paradox of Interactivity*. Bielefeld: transcript.
- Severance, C. (2014). Massimo Banzi: Building Arduino. *Computer*, 47(1), 11–12. doi: 10.1109/MC.2014.19
- Sharp, H., Preece, J., & Rogers, Y. (2019). *Interaction Design: Beyond Human-Computer Interaction* (5th ed.). Indianapolis, IN: John Wiley and Sons. <http://gen.lib.rus.ec/book/index.php?md5=c8831be96c280658b56799d28ea548d5>
- Skivko, M., Korneeva, E., & Korableva, O. (2021). From sustainable habits to sustainable energy use: Social sustainability in the context of digitization. *E3S Web of Conferences*, 250, 06002. doi: 10.1051/e3sconf/202125006002
- Snow, C. P., & Collini, S. (2012). *The two cultures*. Cambridge, U.K.; New York: Cambridge University Press.
- Sparviero, S., & Ragnedda, M. (2021). Towards digital sustainability: The long journey to the sustainable development goals 2030. *Digital Policy, Regulation and Governance*, 23(3), 216–228. doi: 10.1108/DPRG-01-2021-0015
- Statham, N. (2019). Scientific Rigour of Online Platforms for 3D Visualization of Heritage. *Virtual Archaeology Review*, 10(20), 1–16.
- Sternberg, R. J., & Lubart, T. I. (1999). The Concept of Creativity: Prospects and Paradigms. In R. J. Sternberg (Ed.), *Handbook of Creativity* (pp. 3–15). Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511807916.003
- Strate, L. (2004). A media ecology review. *Communication Research Trends*, 23(3), 3–48.
- Strate, L. (2018). Media and protest: Technological change and cultural disturbance. *Explorations in Media Ecology*, 17(3), 231–245. doi: 10.1386/eme.17.3.231_1
- Sutherland, I. E. (1963). *Sketchpad: A man-machine graphical communication system* [Massachusetts Institute of Technology]. <https://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-574.pdf>
- Teo, T. (2023, February 3). *Visualizing Population Density Patterns in Six Countries*. Visual Capitalist. <https://www.visualcapitalist.com/cp/population-density-patterns-countries/>
- VanderWeele, T. J. (2015). *Explanation in causal inference: Methods for mediation and interaction*. New York: Oxford University Press.
- Vervoort, J. M., Keuskamp, D. H., Kok, K., Van Lammeren, R., Stolk, T., Veldkamp, T. (A.), Rekveld, J., Schelfhout, R., Teklenburg, B., Cavalheiro Borges, A., Jánošková, S., Wits, W., Assmann, N., Abdi Dezfouli, E., Cunningham, K., Nordeman, B., & Rowlands, H. (2014). A sense of change: Media designers and artists communicating about complexity in social-ecological systems. *Ecology and Society*, 19(3), art10. doi: 10.5751/ES-06613-190310
- Wagner, R., & Kabalska, A. (2023). Sustainable value in the fashion industry: A case study of value construction/destruction using digital twins. *Sustainable Development*, 31(3), 1652–1667. doi: 10.1002/sd.2474
- Watkins, J., & Russo, A. (2005). Digital cultural communication: Designing co-creative new media environments. *Proceedings of the 5th Conference on Creativity & Cognition - C&C '05*, 144. doi: 10.1145/1056224.1056245
- Xenakis, I., & Arnellos, A. (2013). The relation between interaction aesthetics and affordances. *Design Studies*, 34(1), 57–73. doi: 10.1016/j.destud.2012.05.004
- Zayani, M. (2011). Media, cultural diversity and globalization: Challenges and opportunities. *Journal of Cultural Diversity*, 18(2), 48–54.
- Zhao, J. (2016). Interactive Animation Design: Zbrush+Autodesk+Unity+Kinect+Arduino_3D MotionSensing Tech-Integration. In *Chemical Industry Press*. <https://www.abebooks.com/Interactive-animation-design-Zbrush-Autodesk-Unity/18667156460/bd>