SpringerBriefs on Cultural Computing

Susan Liggett · Rae Earnshaw · Jill Townsley

Creativity in Art, Design and Technology

OPEN ACCESS

Springer

Springer Series on Cultural Computing

SpringerBriefs on Cultural Computing

SpringerBriefs on Cultural Computing presents concise research in this exciting, emerging field. Designed to complement the Springer Series on Cultural Computing, this Briefs series provides researchers with a forum to publish their cutting-edge research which is not yet ready for a full book in the Springer Series on Cultural Computing but which has grown beyond the level of a workshop paper or journal article.

SpringerBriefs on Cultural Computing are shorter works of 50-125 pages in length, allowing researchers to present focused case studies, summaries and introductions to state-of-the-art research. Characterized by fast, global electronic dissemination, they are subject to the same rigorous reviewing processes applied to the Springer Series on Cultural Computing.

Topics covered may include but are not restricted to:

- Creativity support systems
- Digital communities
- The interactive arts
- Cultural heritage
- Digital museums
- Intercultural collaboration.

SpringerBriefs are published as part of Springer's eBook collection, with millions of users worldwide and are available for individual print and electronic purchase. Features include standard publishing contracts, easy-to-use manuscript preparation and formatting guidelines and expedited production schedules to help aid researchers disseminate their research as quickly and efficiently as possible.

Susan Liggett · Rae Earnshaw · Jill Townsley

Creativity in Art, Design and Technology

Springer

Susan Liggett
Reader in Fine Art
Faculty of Art, Science and Technology
Wrexham Glyndŵr University
Wrexham, UK

Jill Townsley
Department of Music and Design Arts
School of Arts and Humanities
Centre for Cultural Ecologies in Art
Design and Architecture
Centre for Biomimetic Societal Futures
University of Huddersfield
Huddersfield, UK

Rae Earnshaw
Faculty of Engineering and Informatics
Centre for Visual Computing
University of Bradford
Bradford, UK

Visiting Fellow
St. John's College
Durham University
Durham, UK

Visiting Professor
Faculty of Art
Science and Technology
Wrexham Glyndŵr University
Wrexham, UK

ISSN 2195-9056 ISSN 2195-9064 (electronic)
Springer Series on Cultural Computing
ISSN 2661-8710 ISSN 2661-8729 (electronic)
SpringerBriefs on Cultural Computing
ISBN 978-3-031-24868-9 ISBN 978-3-031-24869-6 (eBook)
https://doi.org/10.1007/978-3-031-24869-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

The authors dedicate this book to their partners and parents

Preface

From artists' and technologists' perspective this book examines definitions and understandings of creativity that support cross-disciplinary work that impacts society. The gap between creative human processes, technology, and science is the focus of the book which highlights how the impact of new technologies and systems changes the world in which we live. Directly drawing from technologists' and artists' experiences it asks what are the environments in which creativity can survive and grow? The parameters which define such environments are examined.

The shift toward an increasing use of virtual and synthetic worlds in society enables the role of technology in the creative process to be critically assessed. The various ways in which technology may be utilized in the creative process are examined, including technology as computation, synthesizer, interactor, integrator, and as automaton. The key aspects of the digital revolution that most affect creativity and society are explored and evaluated.

Creative processes that involve technology can offer opportunities to investigate the philosophical gap between the subjective and objective relationships that exist between people, places, and things. What are the components in these relationships that enhance creativity? The use of digital images in painting provides a case study on image and representation. How has the narrative on the image been affected by technology? Do we see ourselves differently as a result of this?

Social and cultural systems that appear to be more successful at applying repetitive processes are challenged. These systems are compared to internationally recognized sculptural artworks that involve repetition. The underlying logic of such systems is investigated and analyzed, particularly in their relationship to wider society. How can creativity contribute to an understanding of biomimetic processes that emulate models and systems of nature that can be harnessed to solve complex human problems?

The book evidences the changing borders between art and science and demonstrates how inter-subject collaboration and shared authorship is essential in interdisciplinary and cross-disciplinary projects.

Chapters 2–5 take an artist's perspective of creativity as a slippery concept that can be described as an ability to create something from nothing. In the pre-enlightenment

period creativity was associated with a divine power; during the enlightenment it was considered a collective power, whereas in recently times it is connected to the notion of the artist as an individual genius. This section investigates how the foundations of artistic and scientific research have been developed to create new frameworks for creativity, knowledge production, and collaboration. It provides some case studies to demonstrate how artistic thinking has been assisted by technological developments and asks what stages are involved in the creative process and how they may be harnessed within and beyond the art world. It demonstrates why creativity is recognized as being an important individual trait within a collective endeavor which is important in a drive for entrepreneurship and innovation. Creativity can also have a communal aspect when the interworking of a group inspires individuals to generate new ideas and perspectives when working collaboratively.

Chapters 6 and 7 take a technological perspective of creativity to evidence the progress of computing and digital media as a relevant and useful case study. It asks which visions of the future in the early days of computing have stood the test of time, and which have vanished without trace? Can this be used as guide for current and future areas of research and development? If one Internet year is equivalent to seven calendar years, are virtual worlds being utilized as an effective accelerator for these new ideas and their implementation and evaluation? The nature of digital media and its constituent parts such as electronic devices, sensors, images, audio, games, web pages, social media, e-books, and Internet of Things provides a diverse environment which can be viewed as a test bed for current and future ideas. Individual disciplines utilize virtual worlds in different ways. As collaboration is often involved in such research environments, does the technology make these collaborations effective? Have the limits of disciplinary approaches been reached? The importance of interdisciplinary collaborations for the future is proposed and evaluated. The current enablers for progressing interdisciplinary collaborations are presented.

Chapters 8 and 9 explore the philosophical concerns of time, temporality, and repeated action within creativity in the arts and science. Drawing distinctions between art thinking and design thinking could support new cultural ecologies, capable of critical revaluations of our social, professional, and relational hierarchies. The focus is on understanding artists' processes, to see whether creativity can be recognized and nurtured across all fields and industries. By identifying creative authorship as an integral part of life, we also highlight everyone's singular responsibility toward creating the cultural ecologies that shape society as it navigates the Fourth Industrial Revolution.

Chapters 10–12 explore how art can help science and technology, and how to obtain resources and collaborations for further research and development in the field of creativity? Finally, an epilog draws together the outstanding principles and current issues in a set of propositions.

Where the references are to online papers and documents, the authors have endeavored to provide those that are open source and in the public domain rather than behind a paywall. The current move to a requirement for open-source publication in Europe will assist this situation in the future (on the basis that the tax-payer has already

contributed to the funding of research and development and therefore should be entitled to read the publications without further charge). Where publications are currently behind a paywall, readers can normally only read the abstract and see the list of references before deciding whether to purchase the paper.

There are many references to online sources on the Internet. Readers of the e-book can access these directly as they are embedded in the text as hot links. Some URLs of web pages change over time due to site names being changed by their owners, or the position of the website in the site hierarchy being altered. Where the link does not access the required page, the correct page can often be located by putting the URL into Google. If this doesn't work due to Google's cached copy of the original website having been over-written, then the title of the reference can be typed into Google.

This volume is published as a Springer Open Access book in order to make the e-book freely available to everyone for study and further research, particularly students who may be least able to afford the normal cost of a book. There is a nominal charge for the printed book to cover the cost of printing.

Permissions to include the images used in the figures have been obtained. If there have been any errors or omissions the authors would be pleased to rectify these at the earliest opportunity.

It is hoped that this book makes a useful contribution to an important area of significant ongoing research, development, and application.

Wrexham, UK — Susan Liggett
Bradford, UK — Rae Earnshaw
Huddersfield, UK — Jill Townsley
November 2022

Acknowledgements Thanks and appreciation are due to all those who read draft versions of the chapters and provided comments to improve technical content and readability. However, responsibility for the final text rests with the authors.

Thanks and appreciation are also due to Springer for assistance and support with the editing and production of this book.

Contents

About the Authors

Dr. Susan Liggett is Reader in Fine Art at Wrexham Glyndŵr University. She is Practicing Painter trained in the historical art school tradition, and her work challenges long-established working methods in the light of the digital age. Projects often involve arts and health, resulting in artworks being exhibited in different and varied contexts including galleries, public spaces, conferences, and festivals. As Curator, she has organized exhibitions, chaired conferences, and published work on the interface of art/science. In 2020 she co-edited *Technology, Design and the Arts—Challenges and Opportunities.* https://link.springer.com/content/pdf/10.1007/978-3-030-42097-0.pdf.

Susan has taught fine art to undergraduate and postgraduate students for over 20 years and now spends most of her time supervising research students and painting. She has a Ph.D. from the University of Wales, a Postgraduate Diploma in Painting (M.A.) from the Royal Academy Schools, London, and a B.A. (Hons) Fine Art from Nottingham Trent University. https://www.susanliggett.com/; https://glyndwr.ac.uk/staff-profiles/susan-liggett/.

Prof. Rae Earnshaw is Professor of Electronic Imaging at the University of Bradford, UK, since 1995 (now Emeritus), Honorary Visiting Professor in Creative Industries at Glyndŵr University, and Visiting Fellow at St John's College, University of Durham. He gained his Ph.D. at the University of Leeds and is Chartered Engineer and Chartered Information Technology Professional. He was Dean of the School of Informatics (1999–2007) and Pro Vice-Chancellor (Strategic Systems Development) (2004–2009). He has been Visiting Professor at Illinois Institute of Technology, George Washington University, USA, and Northwestern Polytechnical University, China. He is Member of ACM, IEEE, and CGS and Fellow of the British Computer Society and the Institute of Physics. He has authored and edited 44 books on Computer Graphics, Visualization, Multimedia, Design, and Virtual Reality and published over 200 papers in these areas. Book publishers include Academic Press, Cambridge University Press, Addison Wesley, Springer (UK), Springer (USA), John Wiley & Sons Inc., and IEEE Computer Society Press. Although playing a significant role in academic leadership and management over the past 20 years, he has maintained his research and publication record. He is Member of the Centre for Visual Computing at the University of Bradford which performs world-class research and development in the area of visual image data processing. https://www.bradford.ac.uk/staff/raearnshaw; https://sites.google.com/site/raearnshaw/.

Dr. Jill Townsley is Senior Lecturer, Artist, and Researcher in the Centre for Cultural Ecologies in Art, Design and Architecture, School of Arts and Humanities, University of Huddersfield. She is currently Artist in residence at the Centre for Biomimetic Societal Futures, also at the University of Huddersfield. She studied Sculpture at the Royal College of Art and has a practice-based Ph.D. in Fine Art from Liverpool University, for which she received Gladstone Fellowship from the University of Chester.

Jill has undertaken two residencies as an 'Artist Expert' for SciArt at the Joint Research Centre (JRC) in Italy. The JRC is a community of researchers appointed to advise European Commission policy. In this role Jill has collaborated with JRC researcher in computer

systems and security, Carlo Ferigato, and Nicole Dewandre, scientist and political advisor, currently serving in the European Commission cabinet to the Director General. Jill has exhibited internationally and was awarded the 'Juried Press Award' for artwork exhibited in the '7th International Arte Laguna Prize' held at the Venice Arsenale, Italy. https://pure.hud.ac.uk/en/persons/jill-townsley; https://www.jilltownsley.com/.

Chapter 1
Introduction

Rae Earnshaw

Abstract Human creators are capable of great feats of imagination and inventiveness. History and tradition testify to the masterpieces that have been produced over the centuries. Most of these have been created in human time with the tools that were available. The current digital revolution is providing a new set of tools and environments that creators can use, but this does raise issues such as to how best to preserve traditions and esthetic values that have been built up over many generations. Technology can provide both continuity and discontinuity which has both opportunities and challenges. A number of the factors influencing creativity are summarized, and suggestions made for evaluating the outcomes of the creative process. Mixed interdisciplinary environments offer opportunities for the production of creative works. The rise of commercial art for the Internet and interactive gaming is noted.

Keywords Iterative refinement · Interdisciplinary · Multicultural · Creative augmentation · Digital revolution · Benchmarking

1.1 Traditional Understandings of Creativity

Oxford Languages [1] defines creativity as—"*the use of imagination or original ideas to create something; inventiveness*".

The use of imagination, or original ideas, are assumed in this definition to be by a human creator. Normally what is created involves some kind of tool (e.g., paintbrush, chisel) or process (which may involve other components such as objects or materials) to produce the outcome. It is also assumed that the use of this tool or process is under the direct, or indirect, control of the human. This may involve the need to refine the use of the tool or process as the outcome is being generated, or even change the tool or process. This produces some kind of iteration between the content creator and the outcome. This refinement assumes that the human creator is learning something new during the process of creation and is feeding back into the creative process appropriate changes to the original intentions which result in changes to the outcome. This process is happening in real-time, but it is also human-time and proceeds at an appropriate pace for the human creator. This may take days, weeks, months, or even years.

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_1

1.2 Creativity and Technology

Direct generation of an outcome may be assumed to be under the control of the creator, with the latter being directly involved in any iterative processes that may be required. Indirect generation may involve the use of an amanuensis or other form of support and assistance. The instructions of the original creator may be formalized into a script with intentions and objectives. This could be implemented by mechanical means, or it may be converted into a form to be used by a computer. This could be an algorithm, a virtual environment, or instructions for generating an image, animation, game, or artifact (e.g., by the stereolithography process). This may change the real-time, and human-time, process substantially. For example, the mis-match between human time and computer time is a well-known discontinuity [2]. Human thoughts are typically 0.5 s—this is the time for information from the external world to be incorporated into human conscious experience [3]. By contrast, a 2 GHz chip in a computer can operate at 2 billion operations per sec. In addition, there is a further discontinuity between human time and Internet time. The industry states that one Internet year is equivalent to seven calendar years [4]. This implies that in an Internet context, events can happen much faster than in the real world. These mis-matches can be a barrier and obstacle in some contexts and a liberator and enabler in others.

In addition, computers also change and develop as new algorithms are produced to meet what are perceived to be current needs. Artificial intelligence is one of these developments. A process that is initially described in well-defined terms may be allowed to receive direct information from the process or environment on which it is working, and change the process to maximize its chances of achieving the particular outcomes that are required. This can introduce a degree of uncertainty and unpredictability into the creative process, but it may lead to new outcomes and greater efficiency and effectiveness. It also raises the question of whether the creative process should be essentially deterministic or allowed to contain elements of randomness.

Therefore, the boundary between the solo production of creative works and assisted production is not always a definitive one. It is not a simple either/or situation. When a painter uses a brush it is an augmentation of the human's natural capabilities. Similarly, the artistic process may be assisted by many different kinds of augmentation, some deterministic and others random. Such tools, facilities, and environments change and develop over time.

1.3 Creativity and Context

In addition, creativity does not exist in a vacuum. Gombrich [5] has shown that painters, sculptors and architects are influenced by a wide variety of factors beyond their own ideas and creativity, including the following:

- The context in which they produce their works
- The social and cultural factors in operation in society at the time

- The traditions and works of artists who have preceded them
- The current trends in the created works of their contemporaries
- The availability at the time of tools, materials, processes, and environments.

Therefore, what is being revealed by a particular created work, outcome, or process, is not something that can be fully understood or appreciated in isolation from other works or from society in general. It is part of a wider story of creativity over time, and needs to be seen as part of that story.

Many other definitions of creativity may be given [6]. For example, in assessing an individual's creative ability, Torrance described this as

> a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies: testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results [7]

It can be seen that this can have immediate practical implications. Any company that can devise a mechanism to improve the creativity of its workforce may be able to gain an edge on the competition and produce more appropriate products and services for its customers, and also in a more timely way. Such outcomes may also be at lower cost because of greater efficiency and effectiveness in the processes used.

1.4 Creativity—A Definition

For the purposes of this present volume, creativity may be defined as including one or more of the following aspects:

1. Produce something new
2. Produce new perspectives
3. Produce new understandings
4. Transform the current situation into a new situation.

1.5 Creativity in Mixed Interdisciplinary Environments

Following the Scientific and Industrial Revolutions in the 16th to the nineteenth centuries there has been significant impact on areas outside the immediate disciplines of science and technology. In particular, society has changed as products and services became more widely available. It has also impacted on the arts and humanities by providing new avenues for creativity and exploration. New tools have become available, particularly in the utilization of computers. It has been argued that the rise of computer technology and the Internet constitute in essence third and fourth revolutions, as their effects are so widespread, and also ongoing [8]. As this is part of present experience its long-term effects may not be easy to evaluate or predict.

Technology can provide continuity by making traditional methods and techniques more efficient and effective. In this sense it need not be regarded as an intrusion into traditional practices, but rather adding value to the status quo. It can also provide discontinuity by opening up new perspectives, paradigms, and dimensions of interaction with the observer. This may be regarded as potentially a disruptive force, but it can produce a greater understanding and appreciation of artistic processes and how they are implemented in practice. Utilization of technology can provide an opportunity to reflect on the more manual approaches that preceded it, and the need to preserve the vital and important components from earlier generations.

1.6 Benchmarking the Outcomes of the Creative Process

How then may we value and measure the various outcomes of the creative processes—to determine whether particular tools and environments are meaningful and useful or not? This is a difficult exercise because a degree of subjectivity is involved. In addition, much of current digital content is created to directly serve commercial interests rather than esthetic or philosophical ones. More information is required about the value systems associated with such creative works.

Smith [9] argues that in creating and using digital content, corporations can reflect back to society solely what it wants to see, and which can generate further revenue rather than involve any esthetic values or considerations. What is created and presented is simply a mirror to engage society in its own interests. It has become a commercial exercise. In addition, when considered against the four aspects of creativity proposed earlier, it is unlikely that any of them are satisfied. This could imply it is not genuine creativity in the great traditions of art and design.

> The meaning of the Metaverse, Mark Zuckerberg's virtual realm, has been ridiculed for its dismal aesthetics – but we have got the online world we deserve [9]

1.7 Cultural and Societal Implications

The relationship of creativity with society is increasingly complex. As societies move from monocultural to multicultural there is a wider variety of histories, traditions, and perceptions which are involved.

An Example—Leonardo da Vinci

Artists such as Leonardo da Vinci (1452–1519) were involved with the creation of artistic works and also novel inventions that could have been intended to serve a purpose in the natural world. Both may be seen as aspects of creativity; the former concerned with art and the latter with prototype designs, one of which was a device for a flying machine. However, the principles of flight were not fully understood until 400 years later, at least sufficiently well to be enable an airplane to be constructed

that could fly successfully. This suggests that there was some kind of insight involved in the creation of this work.

It could be argued that this is just evidence that he was a polymath who was gifted in eye and hand in numerous different areas [10]. However, an alternative view is that they were all products of his creative genius which transcended the discipline barriers that later came to be erected to preserve the various subject areas. This in turn led to tension between the arts and the sciences, and misrepresentation [11] which still continues today to some degree - due principally to disciplinary forms of education. In other words, da Vinci's created works can be seen as a continuum which produced new perspectives and new understandings rather than just discrete images and objects to be viewed in isolation (Figs. 1.1 and 1.2).

Fig. 1.1 Portrait of a Musician Leonardo da Vinci 1483–1487 (*Courtesy of* https://www.wikiart.org/en/leonardo-da-vinci/all-works#!#filterName:all-paintings-chronologically,resultType:masonry). Public domain—https://www.wikiart.org/en/leonardo-da-vinci/portrait-of-a-musician-1485

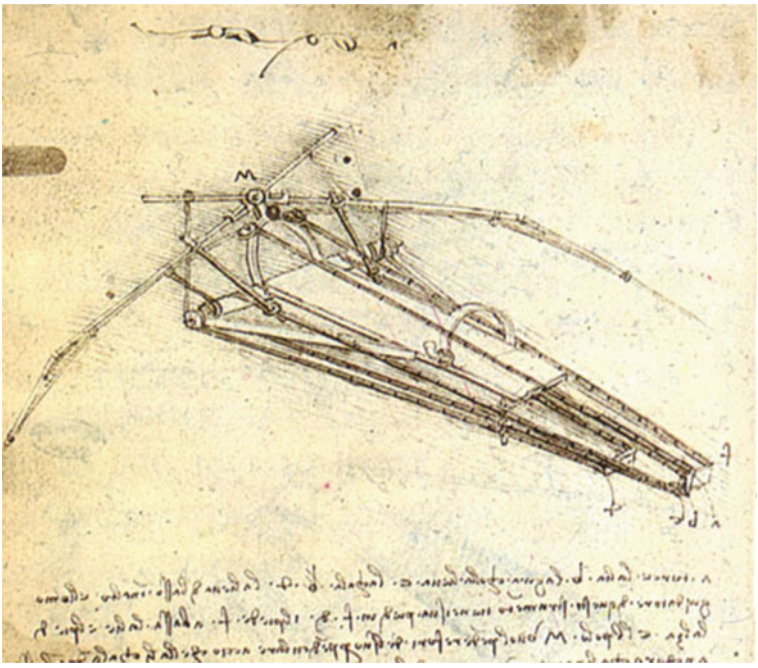

Fig. 1.2 Leonardo da Vinci's design for a flying machine. Public domain—https://commons.wikimedia.org/wiki/File:Design_for_a_Flying_Machine.jpg

1.8 Challenges and Opportunities

The digital revolution may be regarded as intrusion into traditional art practice. However, it can also be an opportunity. For example, it can widen the appeal and the audiences for art and design. Digital technology can also support new dimensions of content—both static and interactive.

Hockney used an iPad to create art works using a brush application created as a software app [12, 13], and submits that technology has transformed his practice. A number of these art works have been exhibited at the Royal Academy of Arts in London [14, 15]. However, this does raise the question of how a 'digital brush' may be compared with the traditional paint brush used by painters down the centuries. Clearly, it has some augmented capabilities and can be changed to produced different effects. Yet it is still a tool, and the artist is free to use it in any way they wish.

Virtual environments are also being used to create digital content both to view and interact with [16].

1.9 Previous Work

An earlier Open Access volume [17] explored emerging aspects of the relationship between artists (and other creatives) and their created works, and also how a variety of tools and environments have facilitated and extended these processes. Such tools encompass computer technology, computer environments, and interactive devices, for a range of information sources and application domains. They also provide new kinds of created works which are able to be viewed, explored, and interacted with, either as an installation or via a virtual environment such as the Internet. This introduces new dimensions of understanding and experience for both artist and the public's relationships with the works that are produced. This has raised a variety of interdisciplinary opportunities and issues. From Leonardo da Vinci to David Hockney the opportunities for artistic and creative expression have transformed the worlds of information of which they are an integral part.

1.10 Conclusion

This present volume continues the analysis and exposition on the themes of art, design and technology, concentrating particularly on creativity.

References

1. https://languages.oup.com/google-dictionary-en/
2. Bowden, B.V.: Faster than Thought. Pitman Publishing, London (1968)
3. https://nymag.com/speed/2016/12/what-is-the-speed-of-thought.html
4. Clark, J.H.: Netscape Time, p. 62. St Martin's Press, New York (1999)
5. Gombrich, E.H.: The Story of Art. Phaidon Press Ltd., London (2007)
6. https://en.wikipedia.org/wiki/Creativity
7. Torrance, E.P.: Verbal Tests. Forms A and B-Figural Tests, Forms A and B. The Torrance Tests of Creative Thinking-Norms-Technical Manual Research Edition, p. 6. Personnel Press, Princeton, New Jersey (1974)
8. https://en.wikipedia.org/wiki/Digital_Revolution
9. Smith, J.E.H.: The Meaning of the Metaverse, pp. 30–32. New Statesman (2022)
10. https://en.wikipedia.org/wiki/Leonardo_da_Vinci
11. Snow, C.P.: The Two Cultures. Cambridge University Press, London (1959, 2001)
12. https://www.royalacademy.org.uk/article/article-david-hockney-ipad-painting-during-lockdown
13. https://www.theguardian.com/artanddesign/2010/may/11/david-hockney-ipad-drawings
14. https://www.youtube.com/watch?v=RNK_Uq_0SyI
15. https://www.royalacademy.org.uk/exhibition/david-hockney
16. Earnshaw R.A.: A new Renaissance for creativity in technology and the arts in the context of virtual worlds. Vis. Comput. https://doi.org/10.1007/s00371-021-02182-7. Open Access. https://link.springer.com/content/pdf/10.1007/s00371-021-02182-7.pdf

17. Earnshaw, R.A., Liggett, S., Excell, P.S., Thalmann, D. (eds.): Technology, Design and the Arts—Challenges and Opportunities, p. 392. Springer, Cham, Switzerland. ISBN 978-3-030-42096-3. https://www.springer.com/gp/book/9783030420963

Chapter 2
Creativity and the Arts: Traditional and New Media

Susan Liggett

Abstract There are numerous theories of creativity from different academic fields, but an overarching unifying theory is almost impossible. Such theories may be specific to a particular context, or they attempt to generalize, with differences in particular disciplines. For example, in psychology the focus is on a micro level with the study of individuals; whereas in the field of innovation research it is on a macro level and often disregards the individual by focusing more on the context. Creativity on a micro level is examined through revealing the process of an individual artist. It introduces 'material thinking'; an intellectual pursuit specific to the making process and reflects on what may be learned from the process of making art. Art can create knowledge that constructs environments and changes lives. This personal knowledge and the work of the hand is sometimes at odds with the technological world, but a study of artistic practices enables us to see and think differently. Artworks have impact beyond the esthetic to influence social, political, and economic spheres.

Keywords Material thinking craftsmanship · Painting · Hylomorphism

2.1 Introduction

The Encyclopaedia of Creativity (2011) suggests that theories either become domain specific or find a general approach to deal with domain-based differences [1]. 'Material thinking' is an intellectual pursuit particular to the making process described by Carter (2005) [2] and it asks, "*what can be learnt from making artworks?*" [2]. It references the work of sociologist Sennett [3] and anthropologist Ingold [4],

The paintings of artist/academic Susan Liggett are presented as a case study to illustrate 'thinking through making' and 'knowing from 'being' that can look *'both inside and outside the field of enquiry at the same time'* (ibid). This mode of thinking involves problem finding that is implicit in the making process, that can be more generative than purely focusing on problem solving.

Craft skills and traditional art practices teach us something that enhances understanding that help develop our digital world, without generating nostalgia for obsolete practices. The artist bridges micro and macro creativity to focus both on the individual and the context in which the artwork is made and consumed by audiences.

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_2

New technology has assisted art practice in challenging its purpose repeatedly over history to make it an important epistemic study.

2.2 Creativity and Its Products

Creativity manifests itself in objects; as Virginia Woolf said, "*Intellectual freedom depends upon material things*" [5]. Artists and scientists are interested in analyzing materials. Beyond the useful scientific analysis of materials to develop products, there is another form of analysis of the characteristics of matter that are more difficult to measure, such as how the color or form of an object makes us feel. Artifacts and artworks play a key role in how we understand the world.

The academic study of 'material thinking' has been critical in helping artists articulate how art practices embody new understandings about individuals and their cultures through the process of making [2]. The importance of Carter's work lies in the cognizance that some art forms exist 'in advance of language' and thus requires 'translation' into language' (ibid). This is the language of creativity that remains elusive, but is explored through practice based artistic research.

2.3 Creativity, Technology, Craft and Skill

In the technological age there is concern that craft skills are becoming obsolete in a drive for productivity. An ability to learn a craft skill through purposeful practice, such as throwing a pot, is often regarded an inferior form of knowledge compared to learning theories and methods from literature. Contemporary sociologist Sennett [3] is an advocate for creative thinking, and rather than considering craft skills in opposition to digital technologies, he thinks of the digital as a new form of craftsmanship. He says that the digital era is not one that should put behind it the traditions of craft; observing that computer coders learn through play and repetition in the same way as a musician learning an instrument [3]. He believes that to make good use of technology, one has to think like a craftsman. In his analysis of what qualities make a good nurse he says

> as with Linux programmers, nursing craft negotiates a liminal zone between problem solving and problem finding; listening to old men's chatter, the nurse can glean clues about their ailments that might escape a diagnostic checklist (ibid).

Against the backdrop of accelerating technology in the 1930s, philosophers Martin Heidegger (1889–1976) and Walter Benjamin (1892–1940) had a concern for tradition and hand skills in relation to technology and art. They both acknowledged technology's great potential, but also that its roles had not been fully explored at the

time, and there could be potential negative consequences. They endorsed an alternative to technology in creative thinking through writing about what can be learnt from art [6, 7].

2.4 Thinking and Making

Anthropologist Tim Ingold (b.1948) draws the distinctions made between theorists and craftsmen; saying theorists make through thinking while craftsmen think through making. His view is that the way we think of making is wrongheaded; as a project that starts with an idea, finds an appropriate material to work with, then ends when this material has taken on its intended form. When creating artworks there is not always an intended idea, it is a process whereby the maker is waiting to receive ideas through the manipulation of materials, rather than imposing them onto the materials from the outset [4].

The process of taking materials from nature to make material objects is known as hylomorphism from the Greek hyle (matter) and morphe (form). Ingold considers the makers process to be "*more humble than those implied by the hylomorphic model*" and thinks of making as a different process; one of growth where the maker is an active participant who 'joins forces' with materials "*bringing them together or splitting them apart, synthesizing and distilling, in anticipation of what might emerge*" (ibid). Ingold said that.

> In the act of making the artisan couples his own movements and gestures – indeed his very life – with the becoming of his materials, joining with and following the forces and flows that brings his work into fruition (ibid, p. 31)

The case study paintings below describe the evolution of a long unstructured process.

Philosopher Gilbert Simondon also questioned hylomorphism. His concept of 'individuation' postulates that form is emergent rather than given in the making process; with man inside the world rather than standing on the outside. Theorist and psychoanalysts Gilles Deleuze and Felix Guattari believed also that hylomorphism fails to acknowledge, "*matter in movement, in flux, in variation*" [8].

2.5 Case Study Susan Liggett Paintings

Painting as a practice remains relevant in the digital age because of what can be learnt from it as a creative process. Technology can distance us from the innate human need to experiment with materials, whereas painting delights our sense of touch, smell and our sight in a visceral, messy and instinctively human way. It can bring us closer to the experience of being human. Paradoxically, by not relying on technology it can teach us about aspects of experience that technology distances us from.

Liggett describes the process of painting as a 'psychological resonance'; the metaphoric vibration resulting from an inner dialog between 'subject' and object' [9]. By this she means that the process connects us with the world in a unique way that is dependent on seeing, playing around with materials, and being fully present in the world.

Liggett, like many contemporary painters, exploits technology without being reliant on it. She turned to incorporating digital photographs into her work after decades of strictly working from direct observation, to question whether if she heightened the illusory quality of the paintings, would they in some way get closer to the lived experience? (Fig. 2.1). The busyness of her life at the time meant that she felt like she had missed the experience of her child growing up so she questioned whether the slow reflective process of painting would allow her memory to unfold in a richer more rewarding way? A photograph taken in a fraction of a second is viewed in the same fraction of time, but with a painting the viewer has to look longer to absorb significance and meaning.

To her surprise, incorporating the photographic element into the paintings had the opposite effect and distanced her memories, with the photographic images not standing in for her memories as she thought they would. They evoked something

Fig. 2.1 Liggett, S (2014), Guaro, oil on board, 15 cm × 18 cm. *Copyright* S. Liggett

Fig. 2.2 Liggett, S (2012) Yellow Spanish Cardigan, oil on board, 38 cm × 55.5 cm. *Copyright* S. Liggett

quite different; the images were familiar but the emotional attachments within the paintings were quite separate. She then abandoned the photograph and allowed the painterly qualities to bring her closer to the inner experiences of events memorized internally (Fig. 2.2). The painterly marks are evidence of her struggles to visualize a memory made more vivid through the physical process of grappling with paint. To quote Henry James in his novel the 'Real Thing': "*the unreal is more precious than the real*" [10].

Paintings can only be truly seen from the first-person perspective and we bring both our eyes and our emotions to the way we respond to them. After viewing Vermeer's paintings, 'The Love Letter' (1669/70) and 'The Music Lesson', (1662/5) Liggett was inspired to make a series of paintings based around the theme of her Mother and her dementia (Figs. 2.3 and 2.4). In the works she wanted to imbue a metaphoric presence of her Mother as she made sense of her struggles with dementia which is represented throught the ghost like arcs that appear incomplete in the image (Figs. 2.3 and 2.4).

Another series of paintings the *Oneiric Hut Series* are inspired by Gaston Bachelard's concept of the "*oneiric house*" which is a "*house of dream-memory*" [11] that exists within each one of us. Liggett spends a lot of time repeatedly drawing the same places or objects in an attempt to evoke and to draw out their poetic qualities in order to do as Cezanne said to "*Dream before nature*" [12]. Trees and the hut are repeatedly drawn from direct observation to test compositions and ideas that culminated in a set of paintings that use this repeated hut motif (Figs. 2.5 and 2.6).

Fig. 2.3 Liggett, S (2018) Music Lesson, 82 cm × 76 cm, oil on linen. *Copyright* S. Liggett

The objects that Liggett draws in her garden take on new meanings as the creative process transforms the hut that is seen before her eyes into something quite different which evocates otherness.

2.6 Creativity and Research

An increased understanding of the unique forms of knowledge that art embodies has led to an increase in artists undertaking research and studying for research degrees. A Ph.D. is now a standard requirement for those teaching in art departments in UK universities [13]. Making art always starts from the first person perspective of the artist which enables conversations to be enriched and imaginations to be evoked.

Most projects as in Ingold's account rely on creativity to help to work things out as one goes along, to determine the completion of the work or the ends conceived in

Fig. 2.4 Liggett, S (2018). Dance of Life, 82 cm × 76 cm, oil on linen. *Copyright* S. Liggett

advance. There is "*interaction and correspondence between articulate and personal knowledge*" [4] and it is this knowledge, our lived experience that shapes our objective reality.

2.7 Conclusions

There is a degree of inherent importance in the making process that can get overlooked when processes are replaced by technology. However, the process of making enables us to connect to the world without rejecting technology. This may be seen in the ways painters have adopted and incorporated new technologies into their work. The proliferation of the digital has re-positioned painting in relation to the screen rather than in its visual representations and has facilitated a recording of first-hand experiences of the world. Social media, Facebook, Instagram, etc. can give us a

Fig. 2.5 Liggett, S. (2016) Half Light Hut, egg tempera on gesso board, 25 cm × 30 cm. *Copyright* S. Liggett

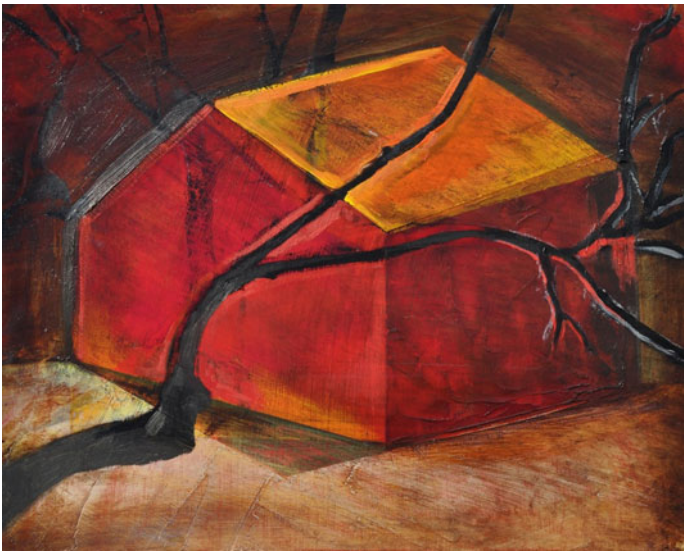

Fig. 2.6 Liggett, S. (2017) Furnished Framework, oil on board, 24 cm × 30 cm. *Copyright* S. Liggett

snapshot of our world, but they can sometimes give us a skewed or distorted view, whereas the painted image tells us something more akin to the human condition.

> Although it was the photography that taught us the modern idea of the image, it is painting that allows us to internalise it [14].

Creativity has become a commodity in the market-place with "*'the creative industries', 'the creative economy' and the 'creative class' paradigms of economic growth*" [15]. 'Means and ends' in contemporary society are often associated with technological advancements. Many artists do not rely on centralized resources, digital transformations or financial investments and largely exist outside of 'markets' and 'political spheres', and often make a living by other means. This can facilitate more independence and greater creativity.

Interest in technology and art is an expanding field and the next chapter explores in more depth how technology is utilized by artists.

References

1. Baer, J.: Domains of creativity. In: Runco, M.A., Pritzker, S.R. (eds.) Encyclopedia of Creativity, 2nd edn., pp. 404–408. Academic Cambridge (2011)
2. Carter, P.H.: Material Thinking: The Theory and Practice of Creative Research. Melbourne University Publishing (2004)
3. Sennett, R.: The Craftsman. Penguin books, London (2009)
4. Ingold, T.: Making, pp. 5, 20. Routledge, Abingdon (2013)
5. Woolf, V.: A Room of One's Own, p. 119. Hogarth Press (1920), Penguin, London (2002)
6. Heidegger, H.: The Question Concerning Technology, and other Essays. Harper Perennial, New York (2013)
7. Donohoe J.: The place of tradition: Heidegger and Benjamin on technology and art. J. Br. Soc. Phenomenol. **39**(3), 260–274 (2008). https://doi.org/10.1080/00071773.2008.11006651
8. Simondon, G.: Individuation in Light of Notions of Form an Information, p. 46. The University of Minnesota Press. https://www.upress.umn.edu/book-division/books/individuation-in-light-of-notions-of-form-and (2005)
9. Liggett, S.: Psychological resonance and its relationship to site in the work of 5 contemporary painters, p. 303. Ph.D. thesis, University of Wales (2008)
10. James, H.: The Real Thing. Macmillan, London (1892)
11. Bachelard, G.: Poetics of Space. Beacon Press, Boston (1969)
12. Merleau-Ponty, M. Cezanne's Doubt, p. 3. (1946)
13. Liggett, S.: Positioning the arts in the research process: perspectives from higher education. In: Earnshaw, R., Liggett, S., Excell, P., Thalmann, D. (eds.) Technology, Design and the Arts—Opportunities and Challenges. Springer Series on Cultural Computing. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-42097-0_2
14. Schwabsky, B.: GI symposium: painting as new medium. ART&RESEARCH: J. Ideas Contexts Methods 32. http://www.studio55.org.uk/anr/v1n1/schwabsky.html (2006)
15. Mould, O.: Against Creativity, p. 11. Verso, New York (2020) https://www.versobooks.com/books/2852-against-creativity

Chapter 3
Creativity and Artist Technologist

Susan Liggett

Abstract The study of creativity in the arts provides an opportunity to present the ways in which new technology has placed new demands on artists. It can also open up new possibilities for the expression of creativity by artists. It expands on the ways in which technology is used by artists as a tool to reflect on the human aspiration for a better future. The artists' collective localStyle is presented as a case study to demonstrate how collaborations between artists, scientists and technologists has led to multidisciplinary and transdisciplinary projects.

Keywords Artists · Scientists · Research · Artists technologist · Collaboration · Digital artwork

3.1 Introduction

The development of new technologies in the 1960s prompted a new generation of artists to experiment with the new media, thus transforming understandings of art. New media art is the term given to all forms of contemporary art made, altered, or transmitted using technologies developed since the 1980s. It is ever-expanding and defies categorization. It includes artists using a range of 'off the shelf' software or learning coding to make artworks that are contained only in digital files. Unlike painting, which has an historic established lineage, new media art has attracted artists from different disciplines and with divergent viewpoints. For example, some artists in the field of music, dance and sculpture have used video as medium to forge new strategies for art making [1].

3.2 Origins of Art and Technology

A characteristic of twentieth century art has been its questioning of painting as a privileged medium for making art. As early as the late nineteenth century the artist Eadweard Muybridge (1830–1904) was a pioneer in manipulating photographic

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_3

images. His motion picture projections were arguably the first time that art and technology coexisted.

In 1966 the artists Robert Rauschenberg (1925–2008) and Robert Whitman (b.1935) founded the non-profit making organization E.A.T. (Experiments in Art and Technology) with engineers from Bell Telephone Laboratories (the research component of the AT&T telephone conglomerate). Traditional art forms such as painting were seen by some as obsolete, and Rauschenberg declared:

> If you don't accept technology you better go to another place, because no place is safe here……Nobody wants to paint rotten oranges anymore [2].

The subjectivity of art has challenged research communities that are entrenched in the scientific method. However, increasingly science communities are working with artists in recognition that their methodological approaches involve problem finding, as opposed to problem solving, and this can lead to productive collaborations.

The European laboratory for Particle Physics CERN recognizes the importance of fostering dialogs between artists and scientists and offers artists residencies, commissions and an events program to build bridges between the two cultures [3]. Dutch artist Rosa Menkman was resident at CERN Collide between 2019–2021, and artworks (Fig. 3.1) resulting from her continuous dialog with physicists and engineers were exhibited at SJSU art galleries in the USA in March 2020 [4].

Fig. 3.1 "Rosa Menkman, Xilitla at Born Digital, Moti, Breda." by Rosa Menkman is licensed under CC BY 2.0

3.3 Digital Artworks

Digital photography has assisted the process of digital transformation of society. For example, 95 million photos and videos were shared on Instagram per day in 2021 [5]. Russell Kirsch (1929–2020), the scientist who invented the digital image scanner that created the first digital photograph (Fig. 3.2), has enabled images to be produced, reproduced, repositioned, refined and combined in unique new ways.

Early experiments in computer art involved computer scientists and mathematicians. In the1960s it was only research laboratories and large corporations that could afford computers. It wasn't until the 'plotter'; a device to hold a pen was developed, that artist such as Frieder Nake became a pioneer in using the computer creatively to produce computer art. Curator Barbara London, on seeing her first computer art show in 1970, thought.

> the programming was outstanding but the art was uninspiring" [7]. She noted that, the engineers were blessed with expansive technical skills but tended to have limited visual imagination [7].

This is no longer the case as cultural computing is now a field in itself with organizations such as The Computer Arts Society that is a specialist interest group of the British Computer Society, (The Chartered Institute for IT) [8]. Since 1990 *Electronic Visualisation and the Arts* (EVA) has organized annual conferences to bring together the application of new technologies to the arts and cultural domains [9].

Fig. 3.2 The first digital image, created in 1957 with a rotating-drum scanner, first invented by NIST. *Credit* R. Kirsch/NIST. Image public domain by NIST. Chosen by Life magazine as one of 100 photographs that changed the world [6]

3.4 Art and Science Collaborative Research

The effectiveness of the contemporary arts in assessing non-art concerns has given it credibility in its role in multi-disciplinary and cross-disciplinary research. This has resulted in artists' interventions becoming more influential in citizen science.

The collaborative artistic platform, localStyle, creates artworks that are displayed in galleries and open public spaces, which helps to highlight problems associated with the climate emergency and resource extraction. The founders, the visual artist Marlena Novak and the composer, Jay Alan Yim, critically re-assess these 'Grand Challenges' and have engaged the expertise of a number of scientists for their projects. They often present works and events together with the collective known as 'Deep Time Chicago', which is part of a global movement working around the theme of the Anthropocene and includes artists, cultural theorists and a biologist [10].

3.5 Case Study—LocalStyle: Choral and Timeslips

The climate change themed projection "Choral", is a project created in collaboration with researchers to raise awareness of the necessity to protect coral habitats. These play an important role in ocean conservation. The habitats that the coral create are fundamental to the sustainability of a quarter of all marine species and the livelihoods of 500 million people around the planet. Novak has said

> these eco systems are in crisis and we hope that the public will be engaged by the beauty and charisma of these creatures and then it will lead to greater appreciation for ocean conservation efforts [11]

Choral is a 12 min audio visual installation commissioned by 150 Media Stream for a sculpturally unique LED panel display (Fig. 3.3).

The resulting artwork from this project is now part of the world's largest permanent digital art projection onto a public building Art on theMART. Initial iterations of the work were on display at 150 N Riverside Plaza Chicago (Fig. 3.4) [12].

Another localStyle art/science project is "Timeslips" (Fig. 3.5); a video installation commissioned by the Haus der Kulturen der Welt, Berlin (HKW) [13] and the Max-Planck-Institut für Wissenschaftsgeschichte in 2019. Exhibited in venues in the USA, Berlin, and London, the artwork places the viewer in the mind of an agronomist working on Mars, who ponders the injustices created by humans attempt to control water on Earth. The title refers to a pause in time caused by Mars having a rotational period slightly longer than that of Earth; with the solution to that difference being a programmed pause between 00:00:00 midnight and 00:01:00. This "Timeslip", when the clock is suspended, is described by the narrator as a time when the past and present collide, and a time used for introspection, reflection, and mindfulness. Inspired by Kim Stanley Robinson's Mars Trilogy novels (1992), the narrator remembers the

Fig. 3.3 Choral (version for Art on the MART), projection April 9–June 29, 2022. Merchandise Mart, Riverwalk looking across the Chicago River. *Photo* Margo Hawk, image copyright M. Novak 2022 and reproduced by permissions

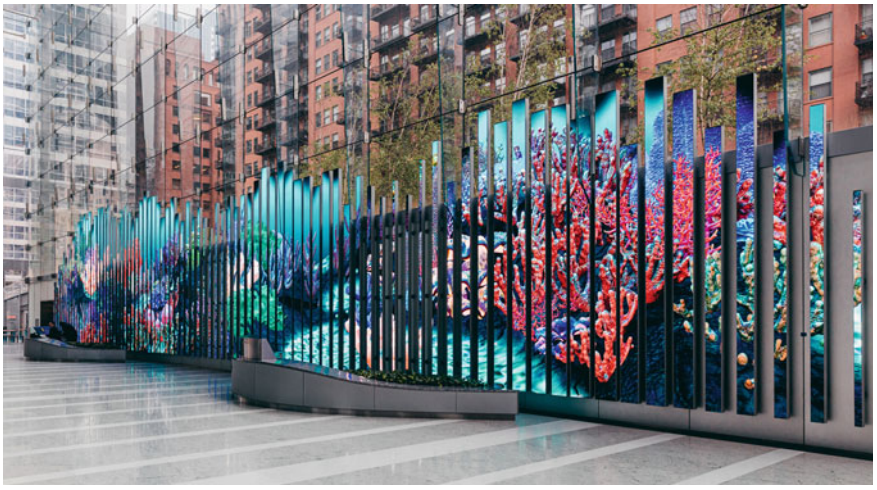

Fig. 3.4 150 Riverside *Choral* installation. *Photo* Michael A. Salisbury, image copyright M. Novak 2019 and reproduced by permissions

absurdity of water management on planet earth, 34 million miles away, where either too much or too little water is problematic.

HKW commissioned localStyle to develop an iteration of Timeslips which resulted in a sculptural assisted readymade "Fourteen Slices of Time" (2020) (Fig. 3.6). Fourteen custom-printed postcards with film stills from "Timeslips" were

Fig. 3.5 "Timeslips" localStyle (Marlena Novak And Jay Alan Yim) with Joslyn Willauer (2019) still [Section Two] from single channel HD video installation with stereo sound. 00:39:35. *Photo* Marlena Novak, image copyright M. Novak 2019 and reproduced by permission

displayed on a simple stand that fits inside an American mailbox to act as souvenirs that trigger memories of Earth.

The Mississippi as an Anthropocene river is the theme of several of localStyle's work. "Re-percussions" (2021) (Fig. 3.7) was an artwork made to support the resistance against the Line 3 oil pipeline in Chicago. This pipeline in Minnesota has been routed through agricultural and sacred land in violation of an existing treaty with the indigenous Anishinaabe native Americans.

3.6 Discussion

Often science and technology may be perceived as the primary driver in a material world, resulting in the arts and humanities being forced into a more reactive position. However, when questions are asked about the values of the science, or the meaning that technological developments have uncovered, these disciplines are often at a loss. It may be regarded as 'beyond science'. At the same time, art practice has been forced by these developments to think of knowledge acquisition outside that of art alone. Therefore, all parties can be beneficiaries of collaboration as has been seen from the case studies in this chapter.

Art is a catalyst for knowledge acquisition with art theory and practice leading to questions outside that of art alone. Curatorial and institutional notions of 'research', as seen in museums and art galleries, complements research in the humanities, the natural sciences, and the social sciences. Curator Tom Holert predicts a sea change in

Fig. 3.6 "Fourteen Slices of Time" (2020) localStyle (Marlena Novak and Jay Alan Yim) with Joslyn Willauer. *Photo* Jay Alan Yim, image copyright M. Novak 2020 and reproduced by permissions

the understanding of the power and reach of artistic research [14]. A new paradigm for artistic research was also debated in 'The Postresearch Condition' EARN/Smart Culture Conference in Utrecht in the spring of 2021. Art is often embedded within transdisciplinary research environments. Artist Amanda Beech describes how when we think of research we are drawn to "ends", but for the arts and humanities knowing requires a conceptualization of something that is beyond the usual measures imposed on knowledge production [15].

3.7 Conclusions

The impact of research all too often is drawn to the use of scientific reasoning and metrics to quantify the social or economic impact of research, but sometimes it takes artists to make sure this knowledge is really understood. localStyle's work is deeply embedded in the dynamics of social and political life. Their critique and reflection on climate action offers more than an esthetic solution; but an ethical, political, and psychological sense of responsibility that raises awareness and makes a relevant contribution to society.

Scientific and artistic thinking give us two complementary tools to understand the complexity of the world with science reducing experience to essential principles and art intensifying and expanding our experiences. The novelist A. S. Byatt said

Fig. 3.7 "Re-percussions" (2021) localStyle (Marlena Novak and Jay Alan Yim) with Mak Hepler-Gonzalez looping HD (1080p) video with stereo sound 00:00:29. *Photo* Marlena Novak, image copyright M. Novak 2021 and reproduced by permissions

art explores connections like those in ways very different from science's ordering – even though scientists are aided by flashes of inspiration [16].

Together art and science give us harmonizing views and explore in different ways the complexity of knowing and understanding the world.

Chapter 4 explores how artistic research exploits the technological age to create new artworks often created in collaboration that reflect upon knowledge production and notions of reality.

References

1. London, B.: Video Art, p. 10. Phaidon, London (2020)
2. Rose, F.: The Big Bang and Tech in New York. New York Times (2015). Available online at: https://www.nytimes.com/2015/11/08/arts/design/the-big-bang-of-art-and-tech-in-new-york.html
3. Arts at CERN. https://arts.cern/programme/artistic-residencies
4. Menkman, R.: Shadow Knowledge Exhibition. https://beyondresolution.info/Shadow-Knowledge (2020)
5. https://www.wordstream.com/blog/ws/2017/04/20/instagram-statistics#:~:text=95%20million%20photos%20and%20videos,Instagram%20platform%20since%20its%20conception
6. Francis, J.: https://www.oregonlive.com/entertainment/erry-2018/05/9e71d5e0cd475/creator_of_worlds_first_digita.html (2007)
7. London, B.: Video Art, p. 25. Phaidon, London (2020)
8. The Computer Arts Society. https://computer-arts-society.com/about
9. Electronic Visualisation and the Arts. http://www.eva-london.org/about/
10. Deep Time Chicago. https://deeptimechicago.org/
11. Gesicki, K.: Chicago artists collaborate with Art on theMART for spring program; focus on climate change. https://columbiachronicle.com/chicago-artists-collaborate-with-art-on-the mart-for-spring-program-focus-on-climate-change (2022)
12. Novak, M., Yim, J.A.: Coral voices. In: Earnshaw, R., Liggett, S., Excell, P., Thalmann, D. (eds) Technology, Design and the Arts—Opportunities and Challenges. Springer Series on Cultural Computing. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-42097-0_11
13. Haus der Kulturen der Welt, Berlin. https://www.hkw.de/en/programm/beitragende_hkw/n/marlena_novak.php
14. Holert, T.: Knowledge Beside Itself. Sternberg Press, Berlin (2020)
15. Beech, A.: Art's Intolerable Knowledge. EARN, Utrecht. http://amandabeech.com/writing/art-intolerable-knowledge/ (2021)
16. Byatt, A.S., cited in Ede, S.: Strange and Charmed. Calouste Gulbenkian Foundation, London (2000)

Chapter 4
Creativity and Virtual Worlds

Susan Liggett

Abstract The relationship between the real world and the internet is explored. The real and the virtual are separate but intersecting and overlapping worlds as far as audiences are concerned. What is the effect of a work created on the internet on the real world, and vice-versa? The rise of the internet and its effect on creativity is examined. Technology has changed the production and distribution of artworks to audiences. Repositories such as art galleries and museums can exist as virtual entities and enable audiences to view, and interact with, artifacts and artworks. Such repositories can change the ways in which audiences view and perceive artworks.

Keywords Virtual reality · Virtual holography · Artificial intelligence

4.1 Introduction

In recent years, there has been a surge in artists experimenting with new technologies to express ideas, expand audiences, or to problematize and critique the implications that technology has on the future. Through making artworks in the internet age, they have tested the limits of technology to explore notions of truth and accounts of reality.

The ways the internet has influenced creativity is explored and questions how human experiences have been impacted by new technologies. It examines the ideas of theorist and philosopher Boris Groys (b.1947). It asks what does it mean for an original work of art to have what Walter Benjamin called an 'aura'; when today the original artwork may only exist as a computer file?

Examples of artworks that use virtual and augmented reality to create immersive environments are explored. A more in-depth case study of the work of British Romanian Artist Ioana Pioaru is presented. Pioaru has developed virtual holography; a new method for art making.

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_4

4.2 Technology and Places of Creativity

Today the internet is the place where artists produce and distribute artworks. The gap has closed between the space of production and the space of exhibiting art, with many artists using their computing device and no longer needing dedicated studios and specialist equipment. The distribution of artwork on the internet has led to the globalization of the artist/author, with social media helping to grow reputations from the local to the global. The internet allows the viewer to see work in progress and to express judgements on quality thus changing the way in which art is critiqued.

According to the art critic and philosopher Boris Groys (b.1947) in the internet age the institutional power of the Museum has collapsed. In his book "In the Flow" (2016) [1] he gives an account of how museums and galleries no longer determine the quality and status of an artwork. Central to the argument is a reminder that although the internet is a virtual space, it has a fixed reference point—'offline reality'; and it refers back to this reality in every interaction 'including economic transactions, surveillance and military operations' (ibid).

British artist Daniel Buzzo uses the internet as a venue for inspiration, production and the distribution of his artwork. Human computer interaction with the internet is a central theme to his work, as demonstrated in his piece *Signs of Surveillance: Dataset for training machine vision systems*" (Fig. 4.1) [2]. His work emphasizes the internet as a machine of surveillance as exemplified by

> It divides the flow of data into small, traceable and reversible operations, and thus exposes ever user to its surveillance [1].

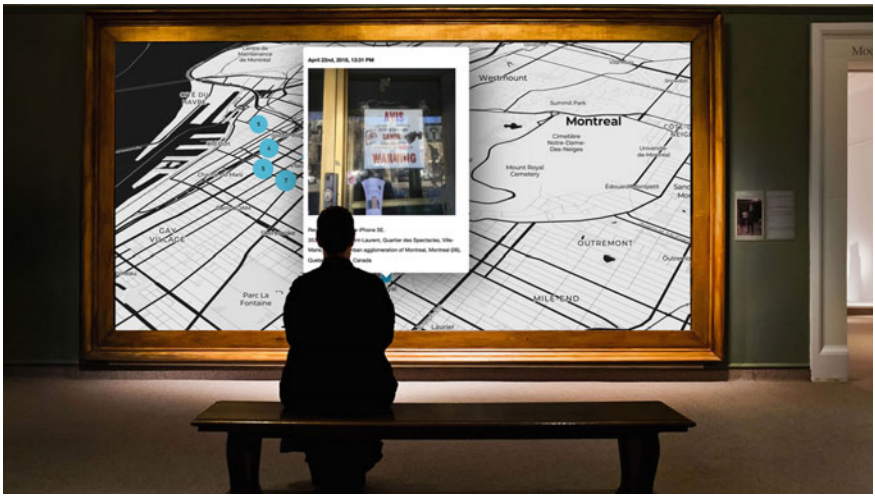

Fig. 4.1 Signs of surveillance, Montreal, Daniel Buzzo. *Copyright* © Daniel Buzzo 2022 and reproduced with permission

A digital image can never be really copied (as it depends on its original context). It is always newly staged or performed and every act of seeing an image or reading a text on the internet is traceable. Buzzo's work acknowledges the impact of this on the status quo, and suggests that secrecy is difficult when one is under constant surveillance, and when the only way we can preclude others is by the use of protected passwords. Groys argues that today subjectivity has become a 'technical construction', and that we have become keepers of secrets; that is by knowing our passwords (ibid).

4.3 Creativity and Being Human

Creativity is a human trait and the making of art is one way in which the individual, who is at the center of a continually changing realm of experience, makes sense of the world. According to Carl Roger, the founder of person-centered therapy, reality for the individual is constructed from the way in which this experience is internalized to construct an internal frame of reference. Making art helps understand human experience through empathy. This is

> The state of empathy, or being empathic, is to perceive the internal frame of reference of another with accuracy and with the emotional components and meanings which pertain thereto as if one were the person [3]

For this reason, the computer cannot create genuine artworks as there is no internal frame of reference for it to originate from unless one is created. Unlike the human creative imagination, where fictions can be created and played out through art, the internet cannot create art because it has no capacity to draw on human experience creating dream worlds that inspire art. Internet information is always information about something in, or derived from, the real world; there are no fictional referents [1].

Ali Nikrang, a research artist at Ars Electronica Futurelab, is fascinated by the limitations of AI-based music, and the artificial creation of meaning. He says that AI may be able to generate pleasing music, but it has no creative value or higher meaning [4].

According to Groys, we perceive artworks as real and tangible things, but

> one can say that on the Internet there is no art and literature, but only information about art and literature [1].

The reality found on the internet is a different kind of reality; one that creates different sorts of experiences. Philosopher Walter Benjamin (1892–1940) in his essay "The Work of Art in the Age of Mechanical Reproduction" (1935) said that artworks change once we can reproduce them, the glow of authenticity that he calls their 'aura' falls away when you are not experiencing the original; suggesting the viewer has a diminished art experience [5].

Fig. 4.2 Kate Darling and Pleo—a robotic dinosaur. Photo Lyla Duey. *Copyright* © Kate Darling, 2022 reproduced with permissions

With human behavior adapting and altering rapidly due to the pandemic Covid-19, the pace of change has been accelerated in the adoption of the virtual. The EVA2021 conference held a symposium panel to ask

> how has art, identity and human digital behaviour' been transformed and what will it mean to be human in a post-Covid, post-digital world? [6].

The Massachusetts Institute of Technology (MIT) Media Lab researcher, Kate Darling, argues in her book "The New Breed" (2021) that we would be better prepared for the future if we started thinking about robots and artificial intelligence (AI) as animals; suggesting that comparing them to humans is limited (Fig. 4.2). We need to think creatively about their potential as collaborators and companions [7]. Scientists in Japan are working on robots to locate and detonate mines that look like spiders, caterpillars and crabs [8].

4.4 Virtual Reality Holography a Case Study—Ioana Pioaru

Pioaru developed the original technique of virtual reality (VR) holography between 2016–21 for her Ph.D. study [9]. This new art form synthesizes the qualities of traditional hand-drawing with the features of holography and virtual reality. It enabled

the showcasing of VR artworks outside of VR space, without the need of a headset. To date one of the limitations in VR media is that perceiving the three-dimensionality of VR artworks depends on wearing a headset through which to access the virtual space where the work resides. Pioaru was frustrated by this as it restricts the number of people who can view the artwork at one time, although access to a Cave could have addressed this to some degree. Her work was therefore only accessible to the wider public in a flattened version via an online 2D galleries. To overcome this, she developed VR holographic art; the first in the world at this time that could be displayed outside VR, while at the same time preserving its volumetric presence. Pioaru defines VR art as the type of artistic content created directly inside the VR environment using an application designed specifically for the purpose of art making. This may be contrasted with computer-generated content presented in VR: making it distinctive and different from anything ever seen before. Holograms do not photograph well—they have to be experienced to fully grasp the intimacy of every hand drawn line sculpted and illuminated in space [10].

The internet space references data from the real world, rather than fictional worlds. Ioana Pioaru's virtual holography artworks present the experience of fictional worlds brought into the real world through drawing. This is an attempt to capture something beyond a perfect replica of an object or thing, but seeks to portray an impression that touches our emotions.

Pioaru's work goes beyond the usual hyper real of holography, through an exploration of the boundaries between sculpture and drawing as in the sculptural and print work as seen in Meditation on a Machinic Cube (Fig. 4.3).

In her holographic works 'Spectral Figures' (2019) (Fig. 4.4) the viewer experiences every hand drawn line that becomes more tangible as you move closer to it as a physical object. To fully comprehend the work a close scrutiny is needed (ibid). 'Warhol' (2019) (Fig. 4.4) is a holograph smaller than human scale, yet every visible sharp illuminated line leaves an impression of what it must have felt like to be the artist making the work. As your eyes trace the lines, a tactile and visceral experience is evoked when viewing the work.

Comparing the drawing 'The Bronte Sisters' (2022) (Fig. 4.5) to hologram 'Spectral Figures' (2019–2020) (Fig. 4.4), the hologram transports the viewer into the process of the drawing itself; helping an understanding of the very human decision-making process that are often hidden in digital media artworks.

Pioaru first started using the 3D-painting virtual-reality Google Application Tilt Brush in 2017 to produce sculptural drawings (Figs. 4.6 and 4.7). She describes how it offers the user a fully immersive experience that is entertaining. However, for her, it was the 3D design platform Gravity Sketch that proved to be the game changer with the level of editability and precision far superior to Tilt Brush [11]. It was through this that Pioaru adapted her VR art making method to the specificity of holography

> instead of drawing on a white background with black strokes, I realised that a much better result would be achieved by drawing with white lines in a dark environment. This method routes the light energy available from the hologram into the drawing lines more effectively; and since the drawing lines usually occupy a much smaller solid angle in total than the background, the relative brightness of the lines can be much higher (ibid).

Fig. 4.3 Meditation on a machanic cube. Installation, Ioana Pioaru, 2017. AnnArt Gallery, Bucharest. *Copyright* © Ioana Pioaru 2022, reproduced by permission

Fig. 4.4 Ioana Pioaru, spectral figures, (2019) Holograph. *Copyright* © Ioana Pioaru 2022, reproduced by permission

Fig. 4.5 Ioana Pioaru Bronte Sisters, pen on paper (2020). *Copyright* © 2022 Ioana Pioaru 2022, reproduced by permission

Ioana Pioaru makes preparatory drawings (Fig. 4.8) to acquaint herself with the volumetric structure of her subject before converting them to light rather than dark outlines within Gravity Sketch. In traditional drawing a 3D object is rendered in 2D, but in virtual space the 2D sketches create the sculptural drawing (Fig. 4.9).

Two recent exhibitions of her work include Gallery 286, London (2022) (Fig. 4.10) [12] and "Holographic Embodiment", Centre for the Holographic Arts, New York (2019) [13].

The post-processing step is done with the help of the holography company Geola who are developing a tool to help artists with this process of preparing files for printing [14].

> Briefly, this consists of reapplying the correct colours to the volumes, setting up the 'holoplane' (a virtual plane that simulates the holographic plate) and positioning an animated camera at the correct distance from the holoplane using a method described by Brotherton-Ratcliffe and Bjelkhagen [15].

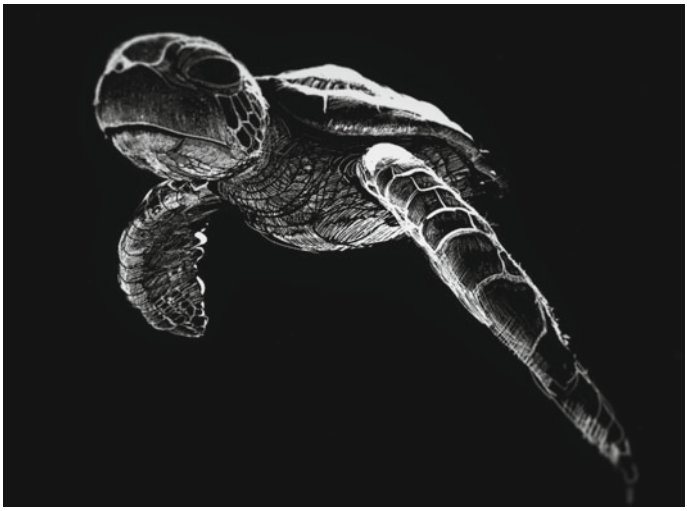

Fig. 4.6 Ioana Pioaru, Tilt Brush snapshot of Sea Turtle. *Copyright* © 2022Image Ioana Pioaru 2022, reproduced by permission

Fig. 4.7 Ioana Pioaru, Tilt Brush snapshot of Pangolin. *Copyright* © Ioana Pioaru 2022, reproduced by permission

More details can be found on this process and how she collaborates with technologists in her comprehensive comparison between SRD and reflection holograms in "Virtual Reality Art Visualised through Surface Relief Digital Holography" [16].

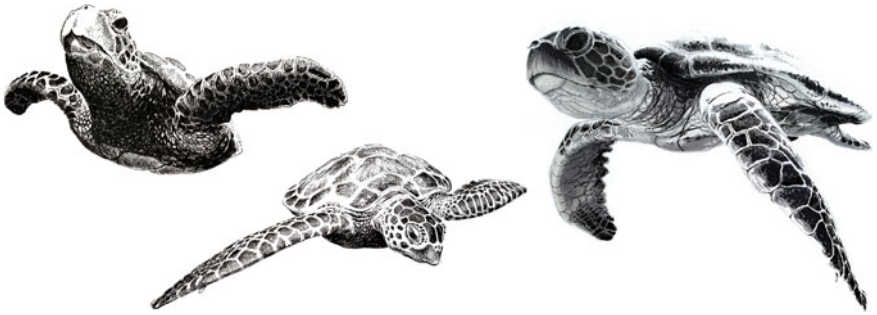

Fig. 4.8 Ioana Pioaru, preparatory ink drawings: Sea Turtle. *Copyright* © Ioana Pioaru, 2022, reproduced by permission

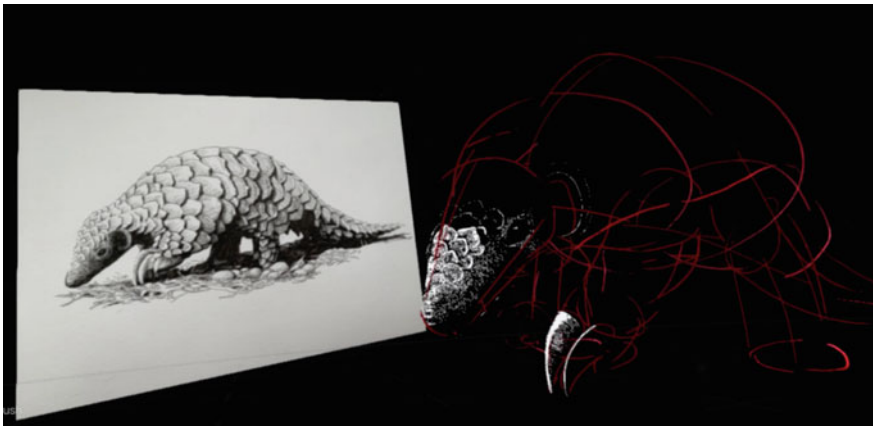

Fig. 4.9 Ioana Pioaru, snapshot from Tilt Brush showing how a 2D sketch is used as a reference for the VR drawing. *Copyright* © Ioana Pioaru 2022, reproduced by permission

The novelty of Ioana Pioaru's work is that it creates VR holographic artworks that can be viewed without the need of a headset, conventionally needed to view all other VR creations (Fig. 4.11).

Creative producer and researcher Luba Elliott, curates AI events and exhibitions including the Machine Learning for Creativity and Design, NeurIPS 2020 Workshop, that brought together artists and researchers together to explore applications of machine learning to creativity [17]. The impact of the fourth industrial revolution on artists and the limits of technology are explored by Frieze [18].

Fig. 4.10 Ioana Pioaru, installation shot, Gallery 286, London (2022). *Copyright* © Ioana Pioaru 2022, reproduced by permission

Fig. 4.11 Ioana Pioaru, 'Spectral Figures: Sea Turtle': two views of the final SRD hologram. *Copyright* © Ioana Pioaru 2022, reproduced by permission

4.5 Conclusions

Artists are attracted to Virtual and Augmented Reality to create immersive experiences. Through experiments with publically available platforms such as Tilt Brush and Gravity Sketch, they have pushed the boundaries of technology to present alternatives for the use of these new technologies. Artist Ioana Pioaru exploits these tools to develop Virtual Reality Holography, a new method for art making.

Artists increasingly exploit and evaluate developing technologies in a range of ways that can lead to new commercial possibilities or in ways that critique its social consequences. They have been inspired by augmented reality, virtual, reality, artificial intelligence and machine learning. An appraisal of these new platforms is both practically and conceptually ongoing more for than two decades since Boris Groys proclaimed in his book a radical shift in our image culture 'from aesthetics to autopoetics'. That is, 'to the production of one's own public self'. As a result of these advances in new technology, artists are working more collaboratively, and in a more democratic way that is decentralized and de-authorized' to reflect and embody our networked selves [19].

Chapter 5 examines how collaborations are generating new ways of working creatively in community spaces to generate new ideas and perspectives on collective rather than individual endeavors.

References

1. Groys, B.: In the Flow. Verso Books, pp. 137, 178. London (2016)
2. Buzzo, D.: Signs of surveillance' in technology, design and the arts—Opportunities and challenges. In: Earnshaw, R., Liggett, S., Excell, P., Thalmann, D. (eds.), Springer Series on Cultural Computing, pp. 159–181. Springer, Cham, Switzerland (2020). https://doi.org/10.1007/978-3-030-42097-0
3. Rogers, C.: A Way of Being, p. 140. Houghton Mifflin, New York (1980)
4. Nikrang, A.: Interaction and Collaboration in AI-based Creative and Artistic Applications, Ars Electronica, Creative Intelligence (2020). https://ars.electronica.art/futurelab/en/research-creative-intelligence/
5. Benjamin, W.: The Work of Art in the Age of Mechanical Reproduction, Penguin Great Ideas. Mass Market Paperback, London (1935)
6. Bowen, J.P., et al.: EVA 2021 (2021).https://doi.org/10.14236/ewic/EVA2021.2
7. Darling, K.: The New Breed. Penguin Random House, New York (2021)
8. Japanese Pet Robots: https://factsanddetails.com/japan/cat26/sub163/item1870.html
9. Pioaru, I.: A practice-based approach to defining maximalism. Ph.D. thesis, University of Chester (2021). https://chesterrep.openrepository.com/handle/10034/625681
10. Pioaru, I.: HoloCentre (2019). https://holocenter.org/holographic-embodiment/ioana-pioaru-spectral-figures
11. Pioaru, I., Stokes, D.: A comparative analysis of virtual-reality art-making software for the production of VR digital holograms. In: SPIE OPTO: Practical Holography XXXIII: Displays, Materials, and Applications (SPIE 2019), San Francisco. https://doi.org/10.1117/12.2512233
12. Gallery 286, London (2022). http://www.gallery286.com/ioana-pioaru/
13. Pioaru, I.: Holographic Arts. New York (2019). https://vimeo.com/451925512
14. Geola: https://www.geola.com/

15. Bjelkhagen, H., Brotherton-Ratcliffe, D.: Ultra-Realistic Imaging Advanced Techniques in Analogue and Digital Colour Holography. CRC Press, Boca Raton (2012)
16. Pioaru, I.: Virtual Reality Art Visualised Through Surface Relief Digital Holography, EVA2020 (2020). https://www.scienceopen.com/hosted-document?doi=10.14236/ewic/EVA2020.26
17. Machine Learning for Creativity and Design, NeurIPS Workshop (2020). https://neurips2020creativity.github.io/
18. Estorick, A.: (2019). https://www.frieze.com/article/wetware-tilt-brush-how-artists-tested-limits-technology-2010s
19. Groys, B.: Going Public. Sternberg Press, Munich, Germany (2010)

Chapter 5
The Creative Process and Social Responsibility

Susan Liggett

Abstract Creativity can have a communal aspect when a group of people have a common goal. With the added advantage of an objective, creativity can be channeled and directed in specific directions and become centered around a focused set of ideas and principles. This can be applied to particular areas of human concern such as civic society, health and well-being, health services, rehabilitation, business regeneration, wartime resilience, and preparing for the future. Examples from these areas are presented in order to understand how creativity has been instrumental in achieving positive goals and has acted as a driver and motivator of change for individuals and communities.

Keywords Civic society · Collective creativity · Collective action · Collective growth · Creative innovation · Creative health · Game play · Online toolkits · Personal development · Social change

5.1 Introduction

The British academic and writer, Oli Mould, suggests alternative ways of thinking about creativity. He sees it not as a neoliberal commodity, but more a freedom to reimagine the future. For Mould, creativity is not an individual trait, that selfishly exploits the marketplace, but a collective endeavor that can improve society without a focus on profit [1]. This modus operandi is evident in many current artist-led creative projects that sit outside the traditional market model, and rather than promoting the individual, they promote artists' collective actions. Socially engaged art practices are collaborative, often participatory, and involve people as the medium for debate or social interaction. This chapter describes the ways in which artists have contributed to the Covid-19 pandemic recovery through community action, useful art, arts in health and digital health. Ty Pawb, a creative collective hub and gallery in Wrexham North Wales is presented as a case study to demonstrates the unique way in which an arts organization can serve communities and foster creative resilience for the public good.

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_5

5.2 Creativity Technology and Social Responsibility

Over recent years, there has been a growing understanding and awareness of the impact that participating in the arts can have on health and well-being. The arts are uniquely placed to help people to gain a greater sense of control over their lives. Having a sense of personal control has been identified as a key to wellbeing [2]. Complementing medicine and care, the arts can improve the health of people, prevent disease, and promote well-being.

Technology has enabled the spread of creative projects and social movements that are key to health and wellbeing through facilitating the documenting and sharing of projects on the internet to new audiences. For example, the British artists and curators Frances Williams, Anthony Schrag and Becky Shaw critique the instrumentalization of the arts in the field of 'arts in health' by staged interventions that are documented for dissemination beyond the live event itself. They curated a number of arts projects with student nurses at Kings College London, entitled "Hiding in Plain Sight" to comment on the UK National Health Service cuts and austerity measures, by offering the arts through social prescribing to ameliorate health service pressures [3].

Their short film, "The Song of the Compassionate Robot" [4] comes from their 'Secret Society of Imperfect Nurses' and takes a near-future vision of nursing. In it the robot nurse suggests that the health care system is broken (ibid) and cannot accommodate human 'creativity', because of a lack of time.

'Creative Health' is the term used to describe a movement of artists and health professionals campaigning for healthcare systems to better utilize the creative arts in supporting health and wellbeing outcomes. The World Health Organization (WHO) recognizes that digital technologies can accelerate health innovation. Digital health has rapidly accelerated since the Covid-19 pandemic and The World Health Summit [5], ViVE [6], Reuters Digital Health [7] and The World Medical Innovation Forum [8] are now staging digital health conferences. One example of digital health innovation is graphic designer/academic Rafiq Elmansy's adherence canvas research project. This focuses on the role of design thinking and technology in improving patient adherence to self-administered treatment technology (Figs. 5.1 and 5.2) [9].

If creativity leads to invention and invention leads to new innovations, then artists will always be necessary. FACT (Foundation for Art and Creative Technology) is

Fig. 5.1 Design driven adherence Canvas, Rafiq Elmansy, 2021. *Copyright* © Rafiq Elmansy 2022 and reproduced by permission

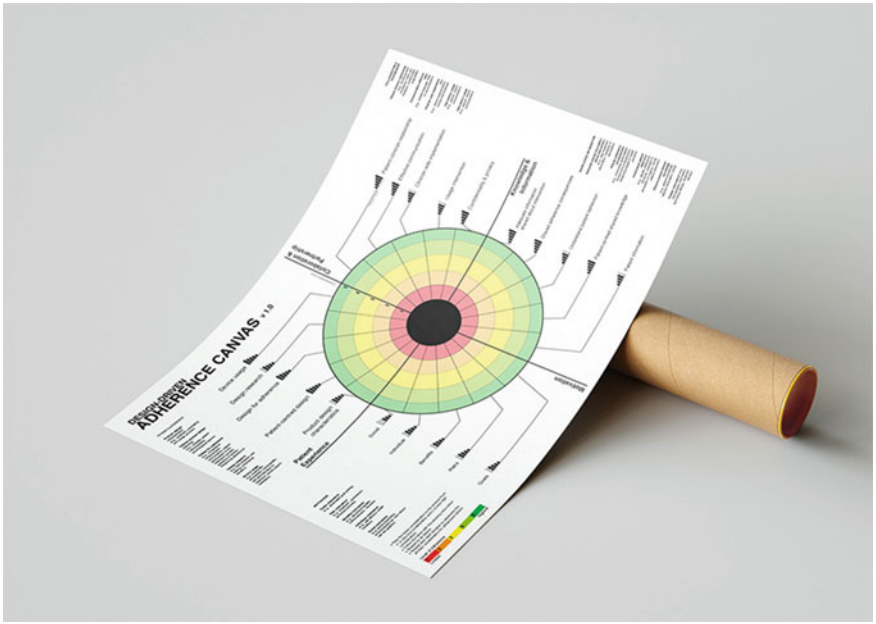

Fig. 5.2 Design driven adherence Canvas, Rafiq Elmansy, 2021. *Copyright* © Rafiq Elmansy 2022 and reproduced by permission

an arts organization in Liverpool that supports digital culture and enriches lives with exhibitions, film screenings and arts projects. Their workshop program DO SOMETHING SATURDAYS is aimed at whole families to engage in technology creatively, such as to bring digital avatars to life and provide an opportunity to play around with augmented reality. Game artist Danielle Brathwaite-Shirley invited the public to join his "Imaginists Society", inviting the public to be part of a real-life video game and is also creating artworks with a group of local young people [10].

American artist and scientist Donna Cox champions the skills in visualization that an artist brings to 'Renaissance Teams' when working synergistically with others in the quest for knowledge [11]. Cox, a pioneer of computer art and scientific visualization, initially worked with research scientists at NCSA (National Center for Supercomputing Applications) because they needed visually literate people to visualize data changes [12]. In some projects she acts as programmer, in others a color expert, a designer, a maker, an animator, or even a producer.

5.3 Useful Art

The internet has enabled the collective growth of social movements such as The Arte Útil (useful art) inspired by Cuban artist Tania Bruguera. This movement advocates

artistic thinking for positive changes in response to current urgencies. According to Brugueras "Arte Útil" should be part of everyday life: it should be a daily exercise in creativity". She sees art as a proposal to society to develop something that can be implemented with 'hope' and 'belief and maintains that 'art is living the future in the present' [13].

The Arte Útil movement is promoted on arts organizations websites such as The Whitworth Gallery [14], and The City Lab, which is part of the Institute of Art and Technology at Liverpool John Moores University School of Art and Design [15]. The Association of Arte Útil has developed a shared open-source research platform known as Decentralising Political Economies [16]. This ongoing project led by the academic John Byrne offers online toolkits, including recoding of seminars, research resources, interviews, artist's activities and action research [17, 18]. This research uses artistic thinking to test other ways of living together in recognition of the limits of current systems and the impact of Covid 19 on society. Mindful of Black Lives Matter and Climate Catastrophe the project will contribute to an exhibition "Economics: The Blockbuster" scheduled for 2023 at the Whitworth, Manchester [19].

5.4 Case Study—Innovative Creative Environments: Lle Celf Defnyddiol, Tŷ Pawb, Wrexham, Wales

A finalist for the Art Fund Museum of the Year 2022, Tŷ Pawb, is a cultural community resource in Wrexham that hosts a public gallery and market under one roof that promotes useful art [20].

Play is recognized as an important component of creativity at Tŷ Pawb, and is nurtured through every element of the site. Even the fittings are designed and made by furniture maker Tim Denton [21] in dialog with Lucicology—the playwork experts y who have a track record of encouraging local authority departments and partner agencies to develop more play-centered policies [22].

Tim Denton's Hippodrome Lampshade was inspired by the Art Deco light that hung in the Hippodrome Cinema in Wrexham until its closure in 1997. The light was restored to its former glory and given a new home in Ty Pawb when it opened in 2018. The bent plywood lampshade was designed for a social engagement project in collaboration with Ty Pawb and the charity CAIS, which is part of Adferiad Recovery helping people with the recovery from drugs, alcohol and mental health problems. The lampshade is being made and produced by volunteer from the charity to develop their skills and encourage personal growth through the design process (Fig. 5.3).

The market trader Steve Tapp has a trainer revival business based in Ty Pawb and sells refurbished trainers all over the world, using the internet (Fig. 5.4). The artistic community and a creative environment are perfect for his business, which in turn brings new audiences to the art gallery. It is an excellent example of the symbiotic relationship between business and art that a useful art space can bring.

Fig. 5.3 Tim Denton lampshade—design for Ty Pawb. Photo Fiona Finchett. *Copyright* © Tim Denton 2022 and reproduced by permission

Fig. 5.4 Wrexham trainer revival. *Copyright* © Steve Tapp 2022 and reproduced by permission

Fig. 5.5 'Me New Do', Anya Paintsil 2022. *Copyright* © Anya Paintsil 2022 and reproduced by permission

Ty Pawb has a strong creative community and has commissioned a short documentary film, which premiered at Black History Month, Wrexham October 2019. It featured artist Anya Paintsil (Fig. 5.5), locktician/hair stylist Rutcher Gomes and braid stylist Admilda Rocha Da Gloria (Teca) who were celebrated for working innovatively with hair [23].

In the film, the three artists discuss how their creative practices developed differently in Wrexham and frequently using similar skills and tools.

During the height of the pandemic Tŷ Pawb launched "Lle Celf Ddefnyddiol", translated as *"The Useful Art Space"; a space that offers communities a virtual and physical place to focus* on creativity. Its aim is to use art as a tool for the people of North-East Wales to 'reimagine' a collective future and to practice the ethos of useful art for social change. "Lle Celf Ddefnyddiol" features as a case study for the Arte Útil movement website [24].

The Lle Celf Ddefnyddiol/the Useful Art Space gets transformed with its flexible furniture to accommodate Bom Dia Cymru (Good Morning Wales); a creative group led by artist Noemi Santos, who works in collaboration with Wrexham's Portuguese language speaking community that creates artifacts to be sold in the market. There is also a group for refugees and asylum seekers working with the artist Ibukun Baldwin, who teaches them textiles, ceramics, printing, embroidery, accessory and product design skills to make things to also sell in the market hall. A separate Maker Space in the gallery supports the development of creative practices that may lead to start-up businesses. The artist and designer, Lorna Bates, was given a residency to showcase her surface pattern designs and launch her business (Fig. 5.6). Tara Dean

worked with the cARTrefu Age Cymru project that places artists in care homes to create a collection of greetings cards. Georgia Nielson, a final year fine art student at Glyndwr University, after graduating, took residency at Ty Pawb as an opportunity to set herself up in a career making rugs and banners (Fig. 5.7).

There are also touring exhibitions at Ty Pawb. For example, the work of 'Tatty Devine' was on show in 2021, in an exhibition supported by the Crafts Council [25]. 'Tatty Devine' is a company founded by the jewelry designers Harriet Vine and Rosie Wolfenden (Fig. 5.8). They promote their craft work (Fig. 5.9) by making kits, entering competitions, setting up workshops and publish blogs on their website [26].

Creativity and collective action are aided by technology. Ty Pawb's website and social media sites have assisted in expanding audiences and have utilized community assets to encourage new collaborations.

Fig. 5.6 Lorna Bates, artist in Residence Ty Pawb, August 2021–November 2021. *Copyright* © Oliver Stephens and reproduced by permission

Fig. 5.7 Georgia Nielson, artist in Residence, Ty Pawb, April 2021–July 2021. *Copyright* © Oliver Stephens and reproduced by permission

Fig. 5.8 Co-Founders of Tatty Devine, Harriet Vine and Rosie Wolfenden. *Photo* Jenny Lewis *Copyright* © Harriet Vine 2022 and reproduced by permission

Fig. 5.9 Cabinet label statement Necklace, Tatty Devine. *Photo* Jenny Lewis *Copyright* © Harriet Vine 2022 and reproduced by permission

5.5 Possibilities for the Future

Art and politics are united in a desire to shape the future and recognize that creativity is an important tool for social change. The field of arts in health, that began as a social movement introducing the arts into hospital and community health settings, is now as global phenomenon. Participatory art projects and other models such as 'social prescribing' in which the arts are integrated into healthcare use technology as a facilitative tool. Digital health is another new field that integrates technology and health and includes mobile health (mHealth), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine. The Arte Útil movement reminds us of the importance of living 'the future in the present' through using art as a social tool to deal with issues that cannot be solved purely politically.

The future is one in which technology plays an increasing role in advancing society. However, Boris Groys warns that the future could be radically changed by technology with both positive and negative consequences such as dehumanization or even cyber wars [27]. The current war in Ukraine is a time to reflect on such a

catastrophic possibility of cyberwars, but art always offers hope. For example, the photograph of the little girl Valeriia fleeing Ukraine and entering Poland has become a symbol of hope. The Ukrainian photographer, Artem Lurchenko, shot the image using a drone and then the French photographer and graffiti artist, JR, used the image to stage a public art event [28] to publicize Ukraine's wartime resilience to the world. He printed out a 148 foot version of the photo onto a tarpaulin and traveled to Lviv enlisting more than 100 Ukrainian volunteers to reveal the artwork in an event shared on Instagram [29]. The artist' aim was to use art to change the war, launching a NFT (non-fungible token) to raise money for those impacted by the conflict.

5.6 Conclusion

What unites artists and politicians is a desire to shape the future, but political ideas quickly become obsolete and give way to the politics of the future. It was the French philosopher Michel Foucault's Heterotopian promise that 'artists transport the present into the future', thus doing their work not for their own time but for the future [30]. Politics shapes the future by its disappearance yet art shapes the future by its prolonged presence [31]. Social movements such as Arte Útil and those promoting arts in health are examples of ways in which creativity enables societies to reflect on the future while living in the present.

Chapter 6 takes a different approach to social responsibility and collaboration through an exploration of creativity in science in technology. Here research environments include interdisciplinary teams and technology enhanced collaborations that allow for more creative and effective projects.

References

1. Mould, O.: Against Creativity. Verso Books, London (2020)
2. Marmott, M.: Closing the Gap in a generation Health Equity Through Action on the Social Determinants of Health. World Health Organization (1980). http://apps.who.int/iris/bitstream/handle/10665/43943/9789241563703_eng.pdf;jsessionid=F203F8BC7149759EC26D3C4836FD6A28?sequence=1
3. Williams, F., Shaw, B., Schrag, A.: Enstranglements: performing within, and exiting from, the arts-in-health "Setting." Front. Psychol. **12**, 732957 (2022). https://doi.org/10.3389/fpsyg.2021.732957
4. https://vimeo.com/178317757
5. https://www.worldhealthsummit.org/
6. https://www.viveevent.com/register
7. https://events.reutersevents.com/healthcare/digital-health-usa
8. https://worldmedicalinnovation.org/
9. Elmansy, R.: Investigating the Role of Creative Design Thinking in Improving Adherence in Patient-Centric Patient-Administered Treatments in Medical Technology Innovation. Northumbria University (2022)
10. https://www.fact.co.uk/event/do-something-saturdays-the-imaginists-society-2

11. Cox, D.J.: Collaborations in art/science: renaissance teams. J. Biocommun. **18**(2), 15–24 (1991)
12. http://www.ncsa.illinois.edu/the-donna-cox-legacy-inspiring-and-visualizing-the-future/
13. http://www.taniabruguera.com/cms/592-0-Reflexions+on+Arte+til+Useful+Art.htmumarte util.net/about/files/files/files/files/reflexiones_sobre_el_arte_util_-_eng_1.pdf
14. https://www.whitworth.manchester.ac.uk/whats-on/exhibitions/upcomingexhibitions/office ofarteutil/
15. https://www.ljmu.ac.uk/research/centres-and-institutes/institute-of-art-and-technology/expert ise/city-lab
16. https://dpe.tools/info
17. Byrne, J.: Negotiating Jeopardy: Use Value and the Work or Labour of Art ten Thije S. Van Abbemuseum/Valiz (2020). ISBN 978-90-829029–0–7
18. Byrne, J.: Negotiating Jeopardy: Toward a Constituent Architecture of Use Byrne J, Morgan E, Sanchez A, Zeleznick A. The Constituent Museum Valiz. Amsterdam (2018). ISBN 978-94-92095-42-8 (2018)
19. https://www.whitworth.manchester.ac.uk/whats-on/exhibitions/upcomingexhibitions/econom icstheblockbuster/
20. https://www.artfund.org/whats-on/museums-and-galleries/t-pawb.
21. https://www.timdenton.info/
22. https://ludicology.com/store-room/research-projects/
23. https://www.typawb.wales/?s=black+history+month.
24. https://www.arte-util.org/about/colophon/
25. https://www.typawb.wales/?s=tatty+devine
26. https://www.tattydevine.com/blogs/news/tagged/cat_women-we-watch
27. Groys, B.: In the Flow, p. 185. Verso Books (2016)
28. http://www.artnet.com/artists/jr/
29. https://www.instagram.com/p/CbnlClWlmVE/
30. https://news.artnet.com/art-world/jr-ukraine-photo-time-magazine-2087543
31. Foucault, M.: Of Other Spaces (Des Espace Autres) (March 1967). foucault.info. Retrieved 09 Jan 2022

Chapter 6
Digital Communication as a Creative Tool

Rae Earnshaw and Susan Liggett

Abstract The progress of computing and digital media is a relevant and useful case study in tools for creativity. Which visions of the future in the early days of computing have stood the test of time, and which have vanished without trace? Can this be used as guide for current and future areas of research and development? If one Internet year is equivalent to seven calendar years, are virtual worlds being utilized as an effective accelerator for these new creative ideas and their implementation and evaluation? The nature of digital media and its constituent parts which integrate technology and various forms of creative media provides a diverse environment which can be viewed as a testbed for current and future ideas. Individual disciplines utilize virtual worlds in different ways. As collaboration is often involved in such research environments, does the technology make these collaborations more creative and effective? Three Case Studies (European Projects) are included to illustrate how creativity can be enabled and stimulated in three kinds of collaborative virtual environments. Two further Case Studies are also included to illustrate how multimedia assets may be harnessed and made available to viewers.

Keywords Computer-assisted creativity · Digital environments · Interaction and collaboration · Cyberworlds · Social media interactions

6.1 Introduction

Humans have had an inherent need to create and since the dawn of civilization they have been visualizing ideas using drawings and models to research designs that communicate concepts that transform and even change traditions. Creative expression can advance ideas and contribute something new, but at the same time this is inevitably linked to the social and cultural experiences of individuals and communities within which these artifacts were created. The quality of the art produced by a nation is a by-product of the extent to which its culture, traditions and economy is developed. Artworks can define these cultures, secure their place in history, and provide a legacy for future generations. Communication is an important element in creativity with openness and integrity required on the part of the communicator and the receiver(s). Such openness shows a willingness to engage with new ideas and

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_6

new cultural contexts, and also to reciprocate through sharing ideas and facts in a quest for new understandings of different concepts.

Thus, the development of human creativity has been transformed by communication sources that transfer information such as speech, writing, images, reading, observing, and printing. Tools have been developed to assist in this, with the printing press being a significant example of how the sharing of information has facilitated the process of learning. The increased capacity to communicate means that many channels are now available allowing communities to be more open and innovative. News ways of thinking and working are able to support the generation of new concepts and ideas more readily than closed environments.

6.2 Computer-Assisted Creativity

New tools, frameworks, and scenarios for the expression of new ideas and new designs, are now available, as well as an increase in the use of digital environments that delivers new types of interactions within which ideas can be generated, revealed, and discovered. The degree to which new technologies advance the creative process is discussed along with the central factors that govern it and how it is augmented and analyzed. The ever-increasing volume of information being generated and circulated by digital systems is equivalent to that brought about by the printing press and could thus constitute a new technological paradigm. The extent to which this may constitute a paradigm shift on the status quo is analyzed. Extracting meaning and knowledge from very large sets of information is a significant challenge often requiring multidisciplinary expertise from a range of discipline backgrounds.

The Internet and the digital world represent a substantial change to the way much of global society operated in earlier eras. It is relevant to consider such a change in the context of Kuhn's concept of paradigm shift evidenced in the scientific and industrial revolutions [1]. There are substantial differences between the medieval era and the modern era brought about by a greater understanding and application of scientific analysis. However, the extent of this change normally only becomes apparent sometime after it has taken place, when there has been opportunity to reflect on the significance of the developments and advancements that have taken place consequent upon the change.

The evidence to date in favor of the Internet and the digital world being a paradigm shift is that they were completely new. The complicating factor is that many of the uses and applications that developed out of this digital framework operated in a more basic form prior to this. Thus, the key question for future historians to answer is whether the Internet and the digital world can demonstrate that major new developments and transformations followed directly from this digital foundation, and that they did not exist before, and would not have followed on naturally from changes in science or society. They were major and transformational and, as for the Scientific Revolution, it is unlikely we would wish to a return (at least in a practical sense) to the state before

the revolution happened. This supports the argument for a paradigm shift associated with the digital world.

What are the key aspects of this paradigm shift in the digital world that can most affect society? In this section it is proposed that connectivity and hybridity enable and facilitate the digital world's transformative effects.

6.3 Interaction and Collaboration

An important component of creativity is communication. This presupposes a degree of openness on the part of the communicator and the recipients(s). Such openness indicates a readiness to receive new ideas and new cultural contexts, and also reciprocate by sharing information. Thus, the development of human creativity has depended to a large extent on speech, writing, images, reading, observing, and printing. The latter took a major step forward with the development of the printing press. This has greatly facilitated the process of learning and the sharing of information.

There are various theories as to what purpose historic cave paintings served but one aspect of their production is clear which is that they all involve an interaction of a human with some kind of tool. The human has used the tool and pigments to create a painting on the wall of a cave to represent in visual form aspects of their live that they have intimate knowledge of such as the hunting of animals.

The relationship of the human to the animal could have been preserved in some form of verbal tradition but through the cave drawing something *additional* to this was also practiced and has been preserved. This form of creative expression arose out of experiences with the external world. A human's ability to interact with their environment in a conscious and creative way is what distinguishes them from the animals that don't interact through conscious reasoning but through instinct and habit. Humans used tools from the earliest eras, formed from various kinds of materials.

6.4 Virtual Environments and Creativity

Tools are utilized in order to interact with a virtual environment where a visual representation of an object can be designed or manipulated (Fig. 6.1). Immersive walk-in environments (such as a Cave—Fig. 6.2) enables the user to be surrounded by a virtual representation as if it were the real world, allowing human potential for creativity to be facilitated by technology. Conversely, if the technology is not fully oriented to the user's way of working then it can act as an inhibitor and a constraint. This underlines the importance of having well-designed user interfaces that enable the users to interact in creative ways with the virtual worlds via the technology.

The name CAVE is thought to be a reference to the allegory of the Cave in Plato's *Republic*. Virtual environments are akin to the allegory in which philosophers chained to the wall of their cave contemplate perception, reality and illusion though watching

Fig. 6.1 Virtual environment—a researcher using VR headset to investigate ideas for controlling rovers on a planet (a team of researchers at ESA's mission control center in Darmstadt, Germany, are investigating new concepts for controlling rovers on a planet and satellites in orbit). This image is licensed under the https://creativecommons.org/licenses/by-sa/3.0/ license

the shadows projected on the wall from objects passing in front of a fire lit behind them. The user's immersion in the Cave as depicted in Fig. 6.2 is thought to provide an additional sense of realism over and above that which would be experienced by observing a 2D image or even a 3D stereoscopic image with depth cues.

Immersion of a human in an environment can provoke a kind of "suspension of disbelief" where the unreality is able to be ignored. Even though the world displayed is artificial, it is made to feel more real because the observer feels they are a participant within it. Virtual environments can offer advantages in the design process and have been successfully used for the presentation and simulation of objects and spaces. Virtual environments are more efficient at helping designers perceive volumes, spaces, and spatial relationships than in 2D environments [2].

Computer technology offers the user the capacity to hypothesize from the current situation and project into the future with millions of alternatives calculated in a fraction of a second. Artificial intelligence techniques can help in the selection of the ones likely to be the most interesting to perform interactive analysis on, that cannot be explored on a human time scale.

Fig. 6.2 Engineering teams can use the CAVE at INL's center for advanced energy studies to tour a virtual nuclear reactor, train staff, orient subcontractors and consider new designs. This file is licensed under the Creative Commons Attribution 2.0 Generic license

Case Study 1—European Project SynchroniCity

"*SynchroniCity"* is an Internet of Things (IoT) project funded by the European Commission (2017–19) [3]. Its aim was to open up the market for IoT-enabled services for cities and communities where barriers prevented local economic and sustainable development. It identified where that the lack of standardized application programming interfaces (APIs) made it difficult to integrate new technologies into city services. The risk of 'lock-in' to systems deters large investments in smart city infrastructures and poses real challenges for local authorities and other city organizations.

In response SynchroniCity developed a framework in the form of a set of technical mechanism that enabled local authorities and technology providers to easily exchange digital products, services and data [4]. The "*Synchronicity Framework"* is built around the Open and Agile Smart Cities (OASC) and Minimal Interoperability Mechanisms' (MIMs), that together provide the technical foundation for deployment of IoT- and AI-enabled services for cities and communities. The MIMs are vendor-neutral and technology-agnostic and can be integrated with existing systems. This means that local authorities and technology providers to easily exchange digital products, services and data.

The project involved 50 developments of products and services across 21 cities across Europe where pilots were SME-led groups. The foci of the pilot studies were as follows: citizen engagement, environment wellbeing, and sustainability.

Sustainable mobility was the focus of one of the pilots providing active travel insights in Antwerp, Helsinki and Manchester. Detailed understandings of cyclists, pedestrians and vehicle movements were made across the cities to promote green travel. The IoT solution combines data feeds from 3 different sensors, with comparative open-air quality data provided by local authorities. Data from all sources was centralized in a dashboard and the following impact was achieved:

- 42 IoT devices were deployed.
- 98 existing IoT devices were connected.
- 111 datasets were consumed.
- 613 new datasets were generated.
- 158 open datasets were produced.
- The Technology Readiness Level of the team's IoT solution improved from 6 to 8.

The pilots demonstrated that through using the framework:

> It is possible to transfer social and environmental impact to local economic activity, as well as opening new market opportunities for both local authorities and technology service providers [5].

> What makes data most useful is not having the most advanced technical capabilities but lowering institutional barriers and identifying the problems that data can address [6].

Technology is evolving at an ever-increasing rate but all too often institutions and organizations and communities do not have easy access to cutting-edge products and services. Therefore, it is essential that technology providers develop hardware and software that does not have barriers to its use. Future-proofing their IoT services is essential, and this can only be done by engaging with communities who use it and incorporate it into their business models.

Case Study 2—i-MareCulture—Advanced VR, iMmersive Serious Games and Augmented Reality as Tools to Raise Awareness and Access to European Underwater Cultural Heritage

i-MareCulture is a European project for digital heritage and virtual museums to raise public awareness of European identity by focusing on maritime cultural heritage. i-MareCulture aims to bring inherently inaccessible underwater cultural heritage to the public by implementing virtual visits, serious games with immersive technologies, and underwater augmented reality. Through the concept of the virtual museum, collaborative research from a range of different scientists, researchers, archeologists, experts and museums ancient sites, many that remain submerged or threatened are brought to life to bring public awareness to important archeological relics. Ten partners from central Europe are developing visualization approaches, and methods including virtual and augmented reality, to improve visibility and help to protect and preserve important archeological heritage.

The project website has a number of tools and games that have been developed, and are open access to the public, including an image enhancement tool and a navigation algorithm. The enhancement tool implements five algorithms aimed at enhancing the

quality of underwater images that can automatically process a set of images within a directory. The navigation algorithm Seafaring Webservice, offers the user a visual simulation of Kyrenia's ancient maritime paths based on real archeological data [7, 8]. By raising awareness of important sites, the regional economic development will improve through tourism and an increased sense of local identity.

Case Study 3—European Project VISTA AR

VISTA AR (Visitor experience Innovation through Systematic Text Analytics & Augmented Reality) is a 4-year European Interreg (European Regional Development Fund) project which started in July 2017 and was extended to December 2021 due to the coronavirus pandemic. It aims to explore and improve visitor experiences for tourist attractions in the South of England and the North of France through creating new VR and AR digital tools.

One site is Exeter Cathedral where virtual reality helmets, tablet and smartphone devices, and immersive room experiences were used to retell history through allowing visitors meet characters from the past and providing access to inaccessible heritage artifacts. The digital tools developed will create new digital experiences in further locations including the National Trust Tin Coast, East Pool mine and the South West Coast Path in the UK and in France at Fougères Castle, the Lorient Submarine Museum and the Gardens of Valloires [9].

The adoption of new technologies by artists and the increasing use of VR and AR as a medium for the production of artworks has stimulated a more detailed reflection on the processes of human creativity. Computer-assisted learning has prompted the study of pedagogy and human learning processes and models of artificial intelligence have initiated a more detailed examination of human intelligence [10–13].

With the increasing ubiquity of the digital environment there are new possibilities for iterating ideas through different visual representations at a greater rate than was possible using previous manual methods. When data is held in digital form it is possible to run simulations and have virtual 'walk-throughs' which has proved particularly important in architectural design and also the design of 3D objects.

With digital technology it is also possible to optimize the designs for situations where there are internal or external constraints, for example, in the total budget for the materials for a building, or construction costs, or in the implementation of an artwork. These include tools for design, mock-ups, real-time simulations, analysis of final representations, and usability testing of final configurations of objects, architectural spaces, and the environments which contain them. For example, designer Thomas Heatherwick's 3d models and drawings of his architectural project "*Vessel*" the controversial architectural centerpiece for Hudsons Yard, New York, can be seen on his website [14]. The Heatherwick Studio recently replaced its CAD data management system with Dassault Systèmes', a Product Lifecycle Management (PLM) solution. This software is used to increase efficiency and reduce the amount of time spent on repetitive design tasks. This can enable more time can be spent by designers on the creative aspects of the projects [15].

Although physical 3D scale models gave previous generations of builders a good understanding of the structure of the building and how it would sit in its environment,

it was difficult to fully understand how it would feel at full scale, particularly to a person moving from room to room inside the building. Therefore, it may be difficult to fully envisage how far computers and associated technology will continue to transform the way information is processed, and the way we think about creating in the future.

6.5 New Media in Cyberworlds

With the rise of new media and digital art forms there has been increasing scope for a wider variety of art objects, particularly those that are able to interact with audiences. Such interactions may change the artwork, or the perspective of the viewer, or both. In addition, time-based media such as video may be used in exhibitions either in free-standing mode, or be able to receive input from viewers to change the content of the video being displayed. A virtual exhibition can also be open to global audiences which can result in a sharing of cultural and ethical experiences across national and international boundaries.

In 2018, Nottingham Contemporary hosted a virtual exhibition titled "*House of Fame*", that was a novelty at the time allowing the viewer to move, rotate and zoom in the exhibits as if they were there in the gallery space [16]. Today, with the acceleration of the virtual experience as a result of the Covid-19 pandemic many galleries offer the experience of virtual exhibitions on their websites (e.g., https://v21artspace.com/the-house-of-fame).

This introduces the concept of exhibition spaces that are borderless with respect to time, space, and audiences [17, 18]. An artist who wishes to exhibit their work in this rapidly changing environment faces two principal challenges. The first is to demonstrate the relevance of the art to today's audiences and the rapidly changing environment. The second is to articulate forms of art which are capable of transcending the boundaries of past traditions and demonstrate new horizons and new opportunities. We are ever-increasingly connected to one another and ever more accustomed to swiping our phones to access digital content. Digital technology can offer a greater level of interaction and increase knowledge and allow for richer experiences of culture if developed intelligently.

Just before the pandemic in 2019 Innovate UK funded a research project at MOSTYN Gallery in Llandudno, North Wales to investigate how audiences want to interact with a public art gallery in the digital age [19]. Principal and co-investigators on the project Clare Harding and Mark Lochrie reflect on the impact of lockdowns and social distancing on the development of their engagement tools. They can use MOSTYN build tools to engage and connect audiences who may not be able to engage physically. These digital experiences can be even more attractive in an age of 'track and trace', zoom parties, and with the use of QR codes to check in to venues. However, the sharing of the head mounted VR displays or wearables still present challenges for technologists, curators and audiences in galleries [20].

Case Study 4—EMAP European Media Art Platform

The European Media Art Platform (EMAP) was created in 2018 to provide an international platform to promote and disseminate interdisciplinary art forms. It was believed that if Europe is to take a different technological path from China or Silicon Valley, it should concentrate on the creative potential of the arts.. Through the European Media Artist in Residence Exchange (EMARE) it enables partners to select artists and artwork for festivals and exhibitions to provide an international platform to disseminate their work.

Rhone (2021) was an artwork by Gil Delindro stemming from a 6-month EMAP residency undertaken in La Becque, Switzerland. A video sound installation on the theme of the environment, global warming and geological sustainability, *Rhone*, explores the symbiotic relation between Glacier erosion and sedimentary geologic formation. The artist used a series of infrasound field recordings and video stills captured in the Ice tunnels of the Rhone glacier over a period of three months.

> The Rhone was once the biggest Glacier of the Alps, being the main responsible for the geologic formation of Lac Leman and the surrounding alpine landscape. This project follows the connection between the retreating "Rhone Glacier" and "Genetti" - an industrial site that sits 100 kilometers after on the Rhone River [21].

Case Study 5—Cop26 Artists and Climate Change

The UK hosted the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow in November 2021. Artists took the opportunity to participate in the conference with musician Brian Eno hosting a panel on how artists can respond to the climate emergency. Significant works included a projected text piece by Jenny Holzer that quotes activist Greta Thunberg. Artist collective *Still/Moving* installed the artwork alongside the COP26 conference site. The work comprised a 70-m-long and six-meter-high artwork stating that there are 'No New Worlds' lit up in neon.

Los Angeles based artist Beatie Wolfe projected her artwork *From Green to Red* onto the contemporary SEC Armadillo auditorium on the banks of the Clyde in Glasgow with the projection covering the entire facade of the building for the UN Climate Change Conference (COP26). The work visualizes rising levels of CO_2 in the atmosphere and is based on 800,000 years of NASA data that informs the interactive video installation by Wolfe. Technology allows artists to take impenetrable and intangible data by scientists and translate it into something they can engage with and absorb.

Wolfe's song accompanies the artwork acting as a giant music video to tell the story of the 50% rise in carbon in the atmosphere due to the activities of mankind. *From Green To Red* was produced in collaboration with world-renowned specialists in visual effects, creative production and immersive experiences The Mill and was premiered at the 2020 London Design Biennale [22].

6.6 Conclusions

Virtual and augmented reality offer spaces which can enable participants to visit places as they were in the past and which are able to impart a real sense of actually being there. Where a historical site is a virtual reconstruction from archeological data, then this experience is facilitating a visit which would be impossible in the real world. This augmentation to real-world experience is both valuable and transformative, as well as being normative for the future.

The affordances provided by the digital world generate new dimensions of connectivity and communication that are particularly relevant in the context of this research. The digital environment can be an enabler in ways not initially envisaged. One example of digital affordances is the many to many paradigm established by the Internet. Networked communications override the one-to-many model used by broadcasters and enable every communicator to be regarded as significant and a contributor to the whole.

References

1. Kuhn, T.: The Structure of Scientific Revolutions: 50th Anniversary Edition. University of Chicago Press, Chicago (2012, originally published 1962)
2. Schnabel, M.A.: Architectural Design in Virtual Environments: Exploring Cognition and Communication in Immersive Virtual Environments. Ph.D. Thesis, University of Hong Kong (2004). http://cumincad.architexturez.net/system/files/pdf/2ccd.content.01425.pdf
3. "SynchroniCity": Funded by the European Commission (2017–19). https://synchronicity-iot.eu/; https://cp.catapult.org.uk/project/synchronicity-and-cpc-work-together-to-build-iot-services-for-cities/
4. The SynchroniCity Framework: https://secureservercdn.net/160.153.137.170/mkw.ee3.myftpupload.com/wp-content/uploads/2020/08/A-guide-to-SynchroniCity-_-small.pdf
5. The SynchroniCity Framework: A Guide to Synchronicity, p. 27.
6. Green, B.: The smart enough city: lessons from the past and a framework for the future. In: The Smart Enough City. MIT Press, Cambridge (2020). https://mitpress.mit.edu/9780262538961/
7. i-mareCulture—Seafaring Webservice for Kyrenia's ancient maritime paths. https://imareculture.eu/downloads/project-tools/navigation-algorithm/
8. Bruno, F., et al.: Virtual tour in the Sunken "Villa Con Ingresso a Protiro" within the underwater archaeological park of Baiae. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XLII-2/W10, 2019 Underwater 3D Recording and Modelling "A Tool for Modern Applications and CH Recording", 2–3 May 2019, Limassol, Cyprus. Available at https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-2-W10/45/2019/isprs-archives-XLII-2-W10-45-2019.pdf
9. VISTA AR: Visitor experience Innovation through Systematic Text Analytics & Augmented Reality. https://www.vista-ar.eu/en/understanding-visitor-experience-interactions-at-cultural-heritage-sites-a-text-analytics-approach/
10. Boden, M.: Can Computer Models Help Us to Understand Human Creativity? http://nationalhumanitiescenter.org/on-the-human/2010/05/can-computer-models-help-us-to-understand-human-creativity/
11. Boden, M.A.: The Creative Mind: Myths and Mechanisms. Weidenfeld and Nicholson, London (1990)
12. Boden, M.A. (ed.): Dimensions of Creativity. MIT Press, Cambridge (1996)

13. Pearce, M.: Boden and Beyond: The Creative Mind and its Reception in the Academic Community. http://webprojects.eecs.qmul.ac.uk/marcusp/notes/boden.pdf
14. Heatherwick, T.: "Vessel" Working Drawings and Models (2019). http://www.heatherwick.com/project/vessel/
15. Dassault Systèmes: Product Lifecycle Management (PLM) Solution. https://www.technia.co.uk/case-studies/heatherwick-studio/
16. Exhibition: House of Fame (2018) https://www.nottinghamcontemporary.org/whats-on/the-house-of-fame-convened-by-linder/
17. Dolinsky, M.: Facing Experience: A Painter's Canvas in Virtual Reality, PhD Thesis, Plymouth University (2014). http://pearl.plymouth.ac.uk/handle/10026.1/32042014dolinsky304581phdAnnotated.pdf
18. Mack, D., Ojalvo, H.E.: Real vs Virtual: Examining Works of Art Online. New York Times (2011, February 7). http://learning.blogs.nytimes.com/2011/02/07/real-vs-virtual-examining-works-of-art-online/?_r=0
19. CANVAS: How do Audiences Want to Interact with a Public Art Gallery in the Digital Age? Innovate UK. https://gtr.ukri.org/projects?ref=104865
20. Harding, C., Lochrie, M.: You can't touch this: what now for user-centred engagement tools in these post-pandemic times? In: Cultural Practices, "Re-evaluate" (2021). 10 June 2021. https://www.culturalpractice.org/article/you-can-t-touch-this-what-now-for-user-centred-engagement-tools-in-these-post-pandemic-times
21. https://emare.eu/works/rhone
22. https://www.dezeen.com/2020/04/24/from-green-to-red-beatie-wolfe-vdf/

Chapter 7
Artificial Intelligence and Creativity

Rae Earnshaw and Susan Liggett

Abstract Collaboration can increase creativity when the interactions are supportive and facilitative. In the real world this could be a group discussion or a collaboration on a particular artwork or project. The computer is increasingly in the loop on these collaborations because it can bring together both local and distant collaborators. In addition, the artwork or project can be displayed on computer screens and the partners can discuss it and work together in real-time. The computer program may also be able to make suggestions to the partners about design options, just as spell-checkers can make suggestions to authors about the grammar and spelling in an article or paper they are writing. The software works in the background and can add value to the overall process of creation, whether this is for a document or an artwork. In this case, the software is working according to pre-determined rules. If the program is allowed to modify itself by taking in input from its own processes, then the rules may change as the program is running. This may be useful in some situations but not in others. The increasing use of artificial intelligence techniques in science, technology, and the arts is reviewed and assessed, and the implications for creativity are presented.

Keywords Artificial intelligence and creativity · Computational creativity

7.1 Enhancing Creativity

An art exhibition is a place where audiences meet works of art that are themselves a form of exposition. In the past, such exhibitions have been static and for a particular time-period and therefore had to be viewed by visitors within that time frame. They have also been mainly works of art such as pictures and drawings, sculptures, or installation art which contained various object components. For groups of people who have common interests, but no opportunity to meet due to geographical separation, online collaboration can provide new opportunities and new environments for sharing and creating. Art galleries are able to move from static displays fixed in time and space to more flexible virtual environments capable of attracting visitors on a global basis. They can also receive input from visitors from their interaction with the displays. This can provide feedback to the artists which could be useful in the creation of future

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_7

works. In addition, online interaction can provide the context for the development of collaborative art works and interactive exhibits.

Liggett et al. [1] and Earnshaw et al. [2] detail projects which bring together artists, scientists, and social media in collaborative processes. It has been demonstrated that these collaborations deliver added value to all participants and enable research and development to proceed at a faster pace.

Enhancing creativity may be accomplished by

- Increasing the diversity of the participants
- Providing anonymity
- Providing creativity triggers through illustrations of tangible products:
  - Prototype
  - Simulation
  - Storyboards
  - Mockups
  - Graphical presentations

Carroll [3] explores whether and how creativity and rationale can have mutually facilitative interactions. Designs usually serve a particular purpose and conform to certain expectations and norms. Designs often open up new issues, raise new questions, and produce new understandings of esthetics. However, this can also create tension in contexts where creativity produces a significant departure from the status quo, and where the effect on those who observe the design may be unpredictable.

7.2 Case Study—Ars Electronica

Ars Electronica is an Austrian cultural, educational and scientific institute active in the field of new media and has a focus on the relationship between art, technology and society. It runs an annual festival, and manages a multidisciplinary media arts R&D facility known as the Futurelab that is guided by the question of what new technologies mean for our lives. Together with artists, scientists, developers, designers, entrepreneurs and activists, explore current developments in the digital society and speculate about their manifestations in the future. The key question is "not what technology can or will be able to do, but always what it should do for us" [4]. Ars Elecronica has a focus of our artistic research and its European ARTificial Intelligence Lab (AI Lab) has Residency program with #Residency 7 awarded to Anna Ridler (GB) and Caroline Sinders (US) for their project 'AI isn't Artificial but Human' in partnership with the Edinburgh International Festival.

Anna Ridler is a UK based artist and researcher who was listed in 2018 by Artnet as one of nine "pioneering artists" exploring AI's creative potential. She is interested in working with collections of information, particularly self-generated data sets, to create new and unusual narratives in a variety of mediums, and what happens when things cannot fit into discrete categories. She is currently interested in the intersection

of machine learning and nature and what we can learn from history. Her artwork "Mosaic Virus" is a video work produced by an artificial intelligence and shows a flowering tulip whose appearance is controlled by the price of a Bitcoin. In this piece, the stripes and colors depend on the value of the Bitcoin and change over time to show how the market fluctuates, and also draw historical parallels from the "tulip mania" that swept across the Netherlands in the 1630s to the current speculation on crypto-currencies. A major part of the project was to create a dataset of 10,000 tulips, all categorized by hand to reveal the human aspect behind machine learning [5].

Caroline Sinders is a US machine learning artist and researcher whose work explores the intersections between natural language processing, artificial intelligence, abuse, online harassment, and politics in digital, conversational spaces. Caroline Sinders's artwork. "Feminist Data Set" (Fig. 7.1) investigates what it means to think through machine learning, to examine every step of the process through a feminist lens, carefully considering every aspect of production, iteration and design. The project carried out data collection in educational and community-based workshops which was then developed to create a feminist data labeling and training system and a data labeling product [6].

"The Feminist Data Set" is an artistic and critical design multi-year project that queries each step of the AI process. It includes

Fig. 7.1 Caroline Sinders, *Feminist Data Set*, collected at SOHO20. Copyright © Caroline Sinders, photographer: Rachel Steinberg (2018) reproduced with permissions

> data collection, data labeling, data training, selection of an algorithm to be used, the algorithmic model, and then the design of how the model is placed in a chat bot (and what the chat bot looks like). Each step exists to challenge and analyse the pipeline of machine learning – is each step feminist, is it intersectional, does each step have a bias and how can this bias be removed? [7].

Sinders found that it evident that the required tool, namely a feminist intervention, does not yet exist and therefore needs to be created and the final result of the project once complete will be a feminist chat bot [5].

"*There is so much that we do not yet see, so much that is still hidden; no one really knows where the digital revolution will take us*" Hannes Leopoldseder (1940–2021), co-founder of Ars Electronica [8].

7.3 Computational Creativity

Defining the process of analysis to enable it to be done automatically by a computer requires the definition of the key parameters. The use of Artificial Intelligence (AI) techniques may provide a degree of augmentation of human capability and present new options and possibilities not conceived of initially by the human mind. This raises the question of in what sense could a machine be described as having creativity? In what sense would this relate to human creativity? If one of the objectives of Google's acquisition of DeepMind in 2014 was to improve the capability of machines to be able to think more like humans, then it will be interesting to see how far computers are able to produce creative solutions to current challenges and problems in order to go beyond what humans are currently able to do [9]. Clearly one of the advantages is direct access to the world's information in Google's databases in forms other than searching for a match to a query. Knowing the right question to ask is often a large part of the problem space. If the question is not known in advance, can new applications of Google's databases provide new and innovative ideas derived from the current information that has been collected and stored? The issue of whether machines could surpass the capabilities of humans is an ongoing debate [10].

Boden proposes [11] that AI techniques can be used to create new ideas in three ways as follows:

1. By producing novel combinations of familiar ideas
2. By exploring the potential of conceptual spaces
3. By making transformations that enable the generation of previously impossible ideas.

In addition, models of AI and creativity and their applications, can offer insights into creativity itself. This is similar to the ways in which computer-assisted learning has provided new insights into human learning by acting as a reflector back to the human. It may be regarded as a by-product of the fundamental aim of a computer-directed process, which could be seen as a way to perform a process faster, more economically, or with greater efficiency and effectiveness. In addition, this learning

process can also be more personalized and adapted to the particular needs and requirements of the individual. By analogy, a computer-directed creative process can be tuned to a particular individual circumstance. From this comparison it can be seen that there is significant potential in exploring how AI can assist the creative process, and in some cases modify it to produce a new and unexpected outcome, or set of outcomes (the third in Boden's three ways listed above).

Computer-assisted creativity usually involves implementing a set of rules or procedures which a human would follow if the process were to be done manually. This offers the advantage of speed and efficiency in generating outcomes. However, it also offers the possibility of amending the rules and observing what changes in the outcome(s) are produced. This can be extended further to the interactive modification of the rules in real-time in order to generate a series of possible outcomes, from which an optimum outcome may be selected. However, the real gains can come when the rules are much more flexible, and the computer is allowed to modify the rules internally. In this case, the user may define a possible starting point and the computer is then free to generate further points, and also new rules which the user may not have thought of beforehand.

Bostrom [12] raises concerns about the prospect of 'superintelligence' and what its implications might be for human society as a whole if there are insufficient controls on initial conditions and potential outcomes.

7.4 Case Study—Deep Mind Technologies Developments

Deep Mind's objective is to produce general-purpose learning algorithms using machine learning and systems neuroscience. Such algorithms can be utilized in a wide variety of applications unlike earlier chess playing programs (such as IBM's Deep Blue) which were tailored to a particular environment and to achieving a predefined goal. These new algorithms were tested in a variety of applications involving games, where clearly human creativity plays a role. Game play is a complex test-bed which is able to evaluate the power of the algorithms. This is because one move at a particular point on the game can have far-reaching implications subsequently. This raises the issue of the optimum move now for the best of a set of possible outcomes in the future. How can a new move be arrived at that has not been played before? This kind of "out-of-the-box" thinking could characterize a human making this move. Can the algorithm improve on this for a wide range of possible moves? The game may have well-defined rules but if the player is in a new situation they have not seen before, what move do they make when they do not intuitively know the outcome? An algorithm that can learn how to play the game faster and better than a human will be likely to make better decisions when in a new situation.

Deep Mind's AlphaGo program was better than the world champion human professional Go player in 2016 [13]. Another program, AlphaZero, was superior to the best programs playing go, chess, and shogi after a short period of learning the games [14]. In science, Deep Mind has made considerable progress in addressing the difficult problem of protein folding [15].

7.5 Conclusions

Factors affecting the digital future include the increasing use of artificial intelligence techniques to handle routine transactions or information requests, as well as new applications and objects; immersive and augmented reality interfaces, and advanced analytic techniques. All these are likely to generate further developments and applications in the digital world and offer opportunity for participation and change.

References

1. Liggett, S., Heald, K., Earnshaw, R.A., Thompson, E., Excell, P.S.: Collaborative research in art, design and new media—challenges and opportunities. In: Proceedings of Internet Technologies and Applications, IEEE, Washington DC, USA (2015). https://doi.org/10.1109/ITA35412.2015; https://ieeexplore.ieee.org/xpl/conhome/7304350/proceeding
2. Earnshaw, R.A., Liggett, S., Heald, K.: Interdisciplinary collaboration methodologies in art, design and media. In: Proceedings of International Conference on Internet Technologies and Applications. Wrexham Glyndwr University, Wrexham (2013), pp. 381–388. ISBN 978-0-946881-81-9
3. Carroll, J.M. (ed.): Creativity and Rationale: Enhancing Human Experience by Design. Springer, London (2013). http://www.springer.com/us/book/9781447141105
4. https://ars.electronica.art/futurelab/en/about/
5. https://ars.electronica.art/aeblog/en/2020/03/26/ai-is-human/
6. https://carolinesinders.com/about/
7. https://carolinesinders.com/feminist-data-set/
8. https://ars.electronica.art/about/de/
9. Guardian: Google acquires UK artificial intelligence start-up Deepmind. Guardian (2014). http://www.theguardian.com/technology/2014/jan/27/google-acquires-uk-artificial-intelligence-startup-deepmind
10. Excell, P.S., Earnshaw, R.A.: The future of computing—the implications for society of technology forecasting and the Kurzweil singularity. In: Proceedings of IEEE International Symposium on Technology and Society, IEEE, Washington, D.C. (2015). https://doi.org/10.1109/ISTAS.2015.7439406. https://ieeexplore.ieee.org/document/7439406?reload=true
11. Boden, M.A.: Creativity and Artificial Intelligence. Artif. Intel. **103**, 347–356 (1998). https://www.sciencedirect.com/science/article/pii/S0004370298000551
12. Bostrom, N.: Superintelligence: Paths, Dangers, Strategies. Oxford University Press, Oxford (2017)
13. Kohs, G., Antonoglou, I., Baker, L., Bostrom, N.: AlphaGo (2017, September 30)
14. Holcomb, S.D., Porter, W.K., Ault, S.V., Mao, G., Wang, J.: Overview on DeepMind and its AlphaGo Zero AI. In: Proceedings of ICBDE 2018. ACM, New York (2018), pp. 67–71. https://dl.acm.org/doi/abs/10.1145/3206157.3206174?preflayout=tabs; https://dl.acm.org/doi/10.1145/3206157.3206174
15. Callaway, E.: 'It will change everything': DeepMind's AI makes gigantic leap in solving protein structure. Nature (2020, November 30). https://www.nature.com/articles/d41586-020-03348-4

Chapter 8
Art Thinking and Design Thinking

Jill Townsley

Abstract A broader spectrum of creative practice is considered more closely, distinguishing between art and design as different entities within the creative tradition. Drawing distinctions between these two forms, could help us understand creativity with more breadth. Creativity may be classified across two domains in the visual arts, art thinking and design thinking. This distinction has a long tradition, however, research outside of practice-based analysis has introduced it as a multidisciplinary tool. Art thinking has in this way expanded beyond art practice and is applied as a general method for observing and utilizing patterns, in all types of creative activities.

Keywords Art thinking · Design thinking · Creative practice · Collaboration · Sculptural installation

8.1 Introduction

A simple example or case study, '*Till Rolls*' (Townsley), offers a situation where analog problems, revealed through art thinking (the process of making) are solved using design thinking and digital technology.

Artist and researcher, Hideaki Ogawa investigates art thinking in his work at *FutureLab*, a research stream at *Ars Electronica*; the Austrian cultural, educational, and scientific institute. He asks: what is the role of art in the twenty-first century? and how may it be applied for the benefit of our future societies? To help answer this he makes a binary distinction between creativity in art and design:

> Art creates creative questions and design creates the creative solutions [1].

Ogawa's proposition re-defines a long-acknowledged contrast between art and design; by addressing creativity as a form of thinking, leading to two distinctly different outcomes. Analyzing the differences and similarities between these two disciplines could identify important breadth across the single term creativity. Such distinctions may also indicate how collaboration may contribute toward more diverse and complete creative outcomes. This knowledge is then applied to consider how creativity may develop across the digital and analog world.

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_8

8.2 Design Thinking

Ogawa outlines the considerable strength of design thinking to influence the world we live in, by providing solutions to problems, resulting in products and services that help navigate existence (Fig. 8.1).

> Design Thinking is effective for creating and shaping creative solutions for the future [1].

The closeness of design thinking to productivity is clear, design evolves the creative solutions, understanding and utilizing possibilities in order to produce products and services.

Design thinking as a creative method became a ubiquitous term in the 1990s, to describe the practical, cognitive, and strategic processes involved in developing design proposals. These processes include, context analysis and framing, ideation and solution generating, creative thinking, sketching and drawing, modeling, and prototyping and testing. They also involve evaluating ill-defined problems with solution focused strategies, and as such has often been an oversimplified route proxy for creative thinking [2].

However, Design Thinking is defined differently by different authors.

> Brown (2008) defines it as "a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity [3]

and Leidtka and Ogilvie [4] frame design as "a systematic approach to problem solving. It starts with customers and the ability to create a better future for them". The concept of artistic interventions has an inclusive definition by Berthoin Antal

> bringing in people, practices, and products from the arts to help address issues their organizations are facing [5].

Design thinking has been criticized by Bruce Nussbaum [6] among others for its textbook methodology that promises quick fixes for organizations at the expense of

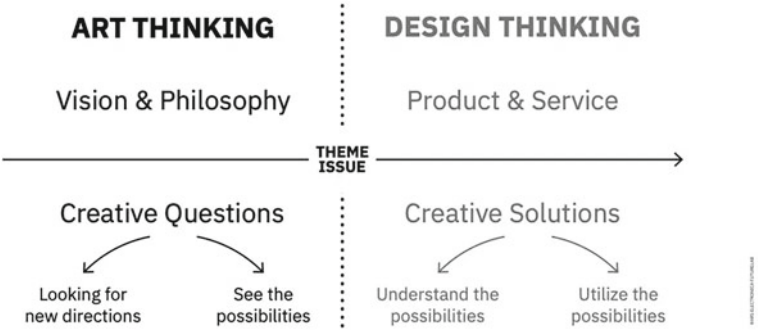

Fig. 8.1 https://ars.electronica.art/futurelab/en/research-art-thinking/, reproduced with permissions

genuine creativity. Critics argue that design thinking has stripped out the messiness of the creative process when conflict, failure, emotions, and constant repetition is at the very heart of the creative process. Through focusing only on what the user wants, there is a significant risk that we may not be asking the right questions.

8.3 Art Thinking

Art Thinking on the other hand, is a much more dispersed activity, adept at raising creative questions, at looking at problems from different angles to define a landscape and propose new strategies and approaches toward the future.

Well established forms of critical thinking are key to discovering creativity in art thinking. Creativity developed with critical understanding, supports creative artwork that has contextual resonance. The aim is not to offer definitive conclusions or answers but to raise questions and to bring into some focus the ever-changing cultural landscape. This complexity is defined by Ogawa

> Art is a catalyst for shaping a better future society, a way to open up new perspectives, encourage curiosity to look at what is behind the scenes and to stimulate creative solutions. Art Thinking is a process of applying artistic thinking and an artful view to a broader range of challenges [7].

With this statement Ogawa acknowledges that the creativity embedded within the art object can be very different to a design object (Fig. 8.2). Creativity engaged in art thinking often deals with conjecture, presenting multiple viewpoints, sometimes simultaneously, posing fuzzy questions and offering incomplete possibilities.

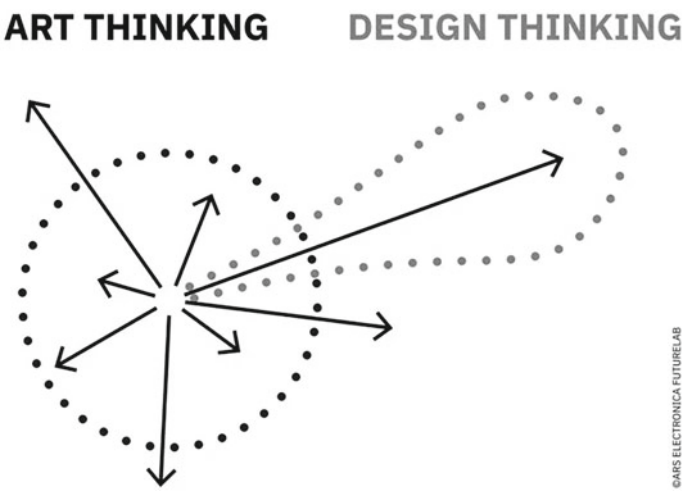

Fig. 8.2 https://ars.electronica.art/futurelab/en/research-art-thinking/, reproduced with permissions

This creativity produces cultural collateral whose aim is not determinative or 'smart', often placed not to solve specific questions, but grow them. This is a risky place for an economic system that predominantly searches for solutions, where success is to cultivate the investment in wealthy returns. For the artist, this form of creativity usually engages contextual referencing, indicating the conceptual landscape the artwork intends to engage with. Successful communication of this open form is completed by the viewer, with the professional critic playing a significant role, placing art thinking within a socially contextual and cultural milieu.

The creative reach of art thinking (the ability of the art object to engage large numbers of people) is difficult to predict, as its success depends on its contextual position within society, including the space and time of its encounter. Through art thinking, creativity can be activated in a way that can be shared within society, from origin to reception, referenced through culture, and relational to the social engagement of people. Relational engagement can draw people together socially across time and space, even traveling across cultural differences. Creativity here is operating in a most powerful and often unpredictable manner, it is often referred to as 'soft power' [8], having the ability to co-opt rather than coerce.

8.4 Case Study '*Till Rolls*'—Art Thinking Collaborating with Design Thinking

In 2008, the Towner Contemporary art gallery in Eastbourne, commissioned a large-scale installation for an exhibition named '*Compulsive, Obsessive, Repetitive*' (2011). At the beginning, the installation was proposed as a creative concept, its existence was potential, on paper only, and it was proposed three years ahead of the gallery's opening, even before the gallery building was constructed.

Till Rolls (Fig. 8.3) is a temporary sculptural installation, conceived to stand on a gridded footprint 5.7 m square, and reaching a height of 3 m at its highest point. It was made only from tightly packed rolls of paper, 10,000 of them. The paper rolls are manufactured for use in shop tills (cash machines) to store accounts and print receipts. It is a simple mechanism to record countless human interactions around trade, cataloging the exchange of goods for money. Each till roll occupied its own space on the floor in a grid system, 100 rows long and 100 rows wide (Fig. 8.4). To form the sculpture, the center of each till roll was extruded, lifted into the space above the grid. At different heights each till roll contributed to a rolling landscape, a three-dimensional graph configuring the hills and valleys of the space above the grid.

To construct *Till Rolls* in the gallery space presented specific contingent problems. The installation time was to be only 4 days, allowing no opportunity for reflexive thinking within the creative process. These are important decisions on shape and form, art thinking traditionally solved in the privacy of the studio, through trial and error, and within the execution of the work. In this case, creative judgments must be

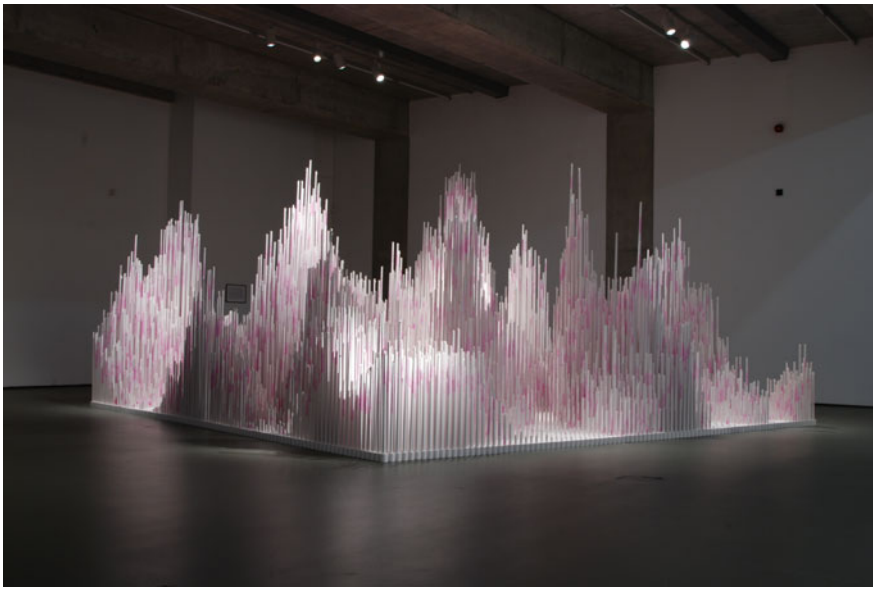

Fig. 8.3 Townsley, J. *Till Rolls.* Material: 10,000 Cash register 'Till' rolls (2011), copyright © Jill Townsley, reproduced with permissions

addressed prior to the making process, while still at the proposal stage. A strategy was needed to ensure that the work would fulfill a specific pre-conceived structure and could be built in the short timeframe. Such problems often require collaboration across other disciplines such as engineering, science, or technology, requiring the skills of design thinking.

8.5 Design Thinking in *Till Rolls*

The next phase of *Till Rolls* offers a good example of simple collaborative creativity located within design thinking, employed to solve specific problems arising from art thinking. The design questions were:

1. How to build the work in only four days, considering the time it takes to manually extrude each of the 10,000 till rolls?
2. How to identify the height of each till roll and where to place it correctly within the sculpture's gridded footprint, so that the correct pre-conceived shape of the whole installation could be realized?
3. How to empower a team of gallery assistants to work independently to construct the sculpture.

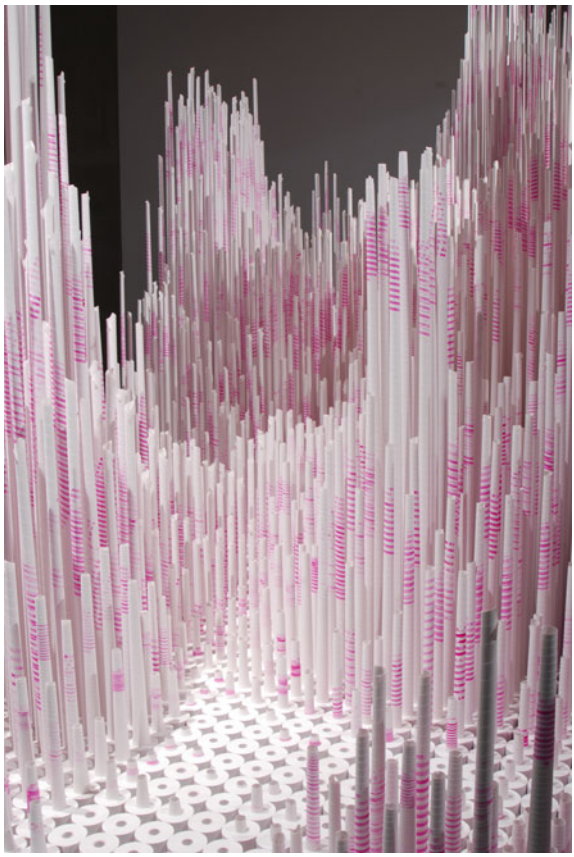

Fig. 8.4 Townsley, J. *Till Rolls*. Detail (2011), copyright © Jill Townsley, reproduced with permissions

To help solve these problems a collaboration was formed with digital design specialist and Principal Lecturer, Dr. Ertu Unver (University of Huddersfield).

Dr. Unver was able to see that digital 3D polygon modeling tools could offer useful creative solutions [9]. The digital space has the advantage of providing a virtual place for creative comparison across potential outcomes. It enabled the artist to make critical and creative decisions toward realizing the final shape of the installation. These are fundamental decisions integral to sculptural practice. Using digital technology in this way formed a bridge between design thinking; to solve the concrete problem, and art thinking; enabling appropriate creative possibilities for the future sculptural form.

Once decisions about the final shape of the work were made, the polygon modeling program was able to capture the digital information in a way that could be reconfigured (Fig. 8.5a). The whole digital sculpture was then cut into 100 slices which allowed the height and position of each of the 10,000 till rolls to be plotted onto two-dimensional graphs. Each graph, once printed, could be used as a map for construction in the gallery. The graph offered the location of each till roll along the bottom axis,

while the vertical axis plotted its height in centimeters. This resulted in 100 graphs collectively articulating a floorplan for the whole work and helping to systemize the process of construction (Fig. 8.5b).

The graphs enabled a changing group of artists assistance, gallery volunteers and community groups, to work independently across each row, with the confidence that each till roll was extruded to the right height to form the sculpture, and then placed in the correct spot on the floor of the gallery (Fig. 8.6).

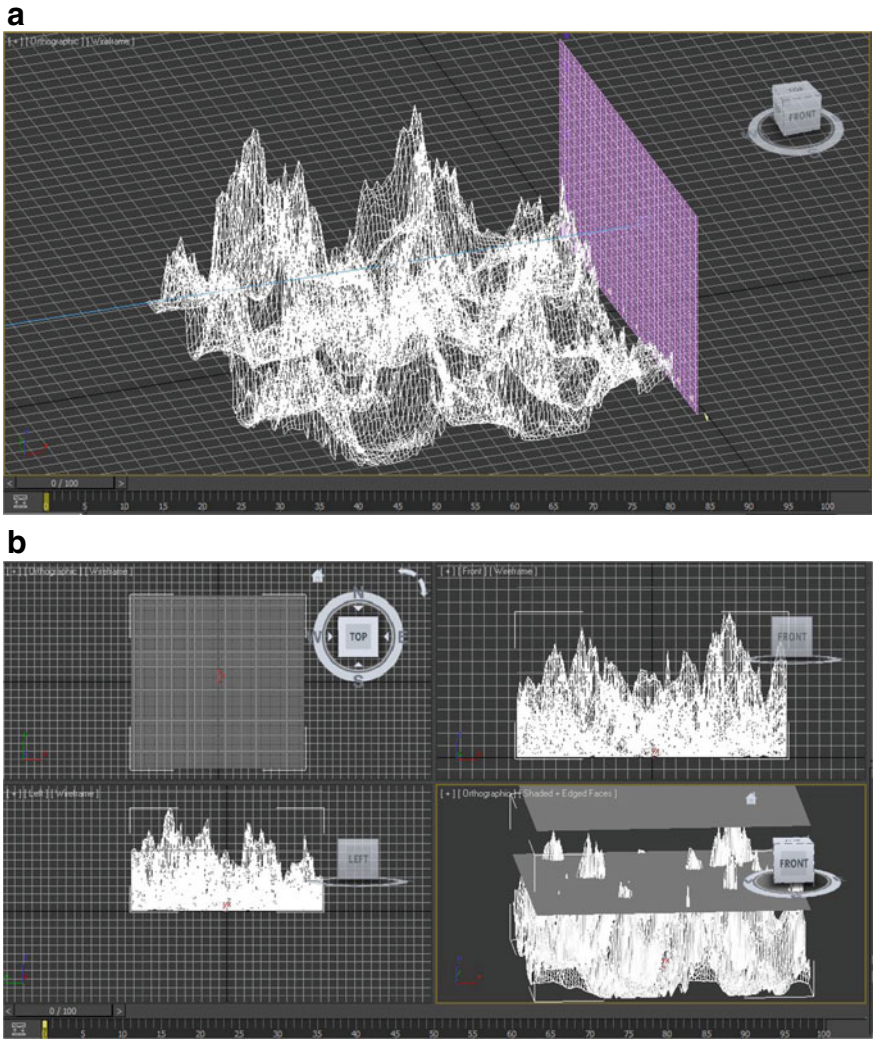

Fig. 8.5 **a**, **b** Townsley J. *Till Rolls* 3D polygon modeling screen shots using 3D Studio Max program (2011), copyright © Jill Townsley, reproduced with permissions

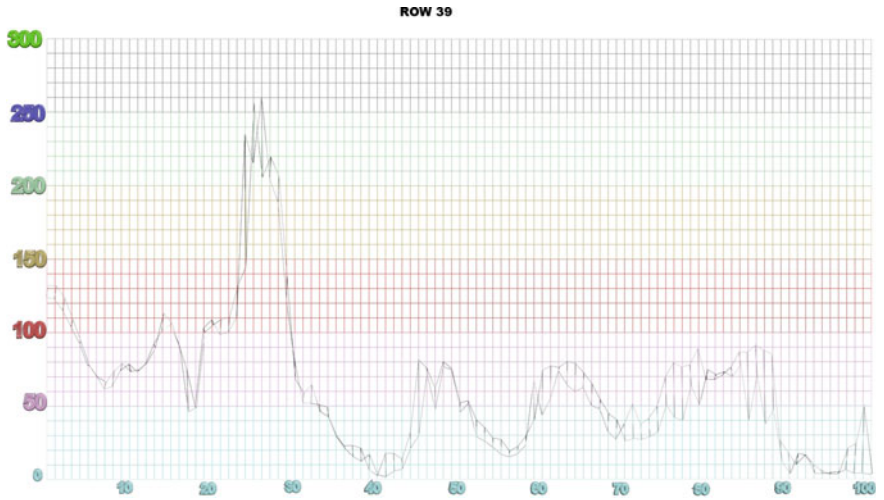

Fig. 8.6 Townsley J. *Till Rolls* Row 39, Graph used to assist the building of Till Rolls (2011), copyright © Jill Townsley, reproduced with permissions

An important outcome from collaboration, across design and art thinking, was that this temporary artwork was organized with a procedural method that could be accurately repeated. Offering opportunities for the work to be rebuilt in different galleries and contexts (Venice Arsenale, Washington DC, Huddersfield Art Gallery).

The virtual object realized through a collaboration of art and design thinking, offered space for critical analysis pertinent to both art and design procedures. It also provided the systematic procedure for the construction of the work with artist, designer, digital specialist, gallery assistance, and public volunteers, all having an individual role within the authorship of the sculptural installation (Figs. 8.7a, b, and 8.8).

8.6 Design Thinking and Art Thinking in the Technological Space

While the difference between art thinking and design thinking as defined by Ogawa is clear, there is also a coming together of art and design especially evident in digital technology. There are many creative examples of contemporary artists expanding their studios to include designers and artists working together. Technology companies have also expanded to broaden their skills to include both artists and designers with an understanding that each offer different forms of creativity.

> Art thinking created the first iPhone; design thinking made it a manufacturable, cultural phenomenon [3].

Fig. 8.7 **a**, **b** Townsley J. Installing *Till Rolls* at the Towner Art Gallery (2011), copyright © Jill Townsley, reproduced with permissions

Fig. 8.8 Townsley J. Installing *Till Rolls* at the Venice Arsenale, Arte Laguna Prize (2013), Copyright © Jill Townsley, reproduced with permissions

In Ogawa's model the value of creativity in design is its preoccupation with problem solving, in contrast to creative artistic interventions that are concerned with problem finding. This makes the discourses of creativity within technology subtly different too, with the separation between them not clearly defined in the single term. John Lasseter, formerly chief creative officer at Pixar, and now head of animation at Skydance Animation, describes the equation this way: "*Technology inspires art, and art challenges the technology*" [10].

To understand how to improve new products, feedback and critique is necessary, and this is where artistic thinking can help, as Jobs points out this happens very often across traditional disciplines.

> It's in Apple's DNA that technology alone is not enough—it's technology married with liberal arts, married with the humanities, that yields us the results that make our heart sing [11].

Art and design students practice critique often defined by the humanities or socially through worldly experience that enables them to develop their creative work. This connects them to a cultural context, a relational world that is always changing, always infinitely complex.

8.7 Conclusions

One way to address how creativity may operate across the analog and digital divide in the future, is to look at the way visual arts and artists engage different forms of creativity across different visual art disciplines today. The aim is to consider how creative process can generate social justice and produce cultural value [12].

Defining creativity as distinctly different in its action when applied across design or art practice is a useful tool to analyze. It is also relevant to understand how creativity supports critical thinking, and even how it can drive cultural change.

Ogawa provides us with a deeper understanding of the forms of creativity that may be appropriated, through collaborative means, to realize and construct contemporary artwork. While creativity is known to be integral to all artistic endeavor, artists are also increasingly collaborating with other disciplines to broaden the forms of creativity available to them. This enables artists to develop artwork fit for our highly interfaced and conceptually broad contemporary contexts. Often this produces artwork that can interact with technological development to help define our societal selves. Creativity can investigate our relationship to external and conceptual systems, such as time, temporality and how we experience creative communication from source to interpretation through reception.

The next chapter deals with contextual referencing and its fluidity within socially agreed cultural systems.

References

1. Ogawa, H.: Art Thinking. Ars Electronica Futures Lab. Electronic resource: https://ars.electronica.art/futurelab/en/research-art-thinking/
2. Cross, N., Dorst, K., Roozenburg, N. (eds.): Research in Design Thinking. Delft University Press (1992)
3. Brown, T.: Design Thinking. Magazine article. Harvard Business Review (2008)
4. Leidtka, J. Ogilvie, T.: Designing for Growth: A Design Thinking Tool Kit for Managers. Columbia University Press (2011), p. 4
5. Berthoin, A., Straub, A.: Artistic Interventions in Organisations: Finding Evidence of Values-added. Creative Clash Report. WZB, Berlin (2013)
6. Nussbaum, B.: Creative Intelligence: Harnessing the Power to Create, Connect, and Inspire. HarperBus (2013)
7. Ozawa, H.: Art Thinking. Ars Electronica Futures Lab. Electronic resource: https://ars.electronica.art/futurelab/en/research-art-thinking/
8. Joseph, S.: Soft Power: The Means to Success in World Politics. Public Affairs, New York (2004)
9. Unver, E., Townsley, J.: Integration of 3D Technologies to Communicate Large Scale Sculpture Installation: Till Rolls Case Study. University of Huddersfield (2011). https://pure.hud.ac.uk/en/publications/integration-of-3d-technologies-to-communicate-large-scale-sculptu
10. Lasseter, J.: In: O'Keefe, A., Dweck, C., Walton, G. (eds.) Having a Growth Mindset Makes It Easier to Develop New Interests. Harvard Business Review (September 2018). https://hbr.org/2018/09/having-a-growth-mindset-makes-it-easier-to-develop-new-interests
11. Jobs, S.: Apple Launches iPad 2. San Francisco Live Event Apple Newsroom (2011)
12. Mould, O.: Against Creativity. Verso Books, London (2020)

Chapter 9
Time and Temporality: Creative Reception and Repetition

Jill Townsley

Abstract *Spoons* is a sculpture that holds contextual reference through its relation to time. Temporality is made visible as the sculpture randomly collapses in the gallery space over a period of time. It looks at the way time and temporality interact with creativity to bring meaning to an artwork. A proposition is made that meaning is constructed through a process of relational connection between the artwork and the viewer. Communication and meaning are contingent on an ever-changing interaction between origin and reception. This is a creative act, and as such meaning is creative and contingent on the time and the temporality of the moment of encounter. However, moments are always changing, so, meaning is always changing too, as time alters our socially agreed cultural contexts, interests, and concerns. The proposition is that through art thinking, creativity becomes a social event, constructed between origin and reception, fluid and relationally positioned in time and space through repetition. The case study reveals that meaning can be creative and transient, as opposed to specific or fixed, and that these creative constructs depend on time, culturally agreed contexts, and relational conditions. Consideration is also given to how the digital space can disrupt our understanding of time and temporality, as it traverses the analog and digital worlds.

Keywords Time · Temporality · Digital space · Analog space · Creative context · Exhibition · Cultural currency · Repetition

9.1 Introduction

Large and temporary installations, such as *Till Rolls*, exist only during the fleeting moment of their construction. They present visual art as an event which is received in time, as opposed to an art object as a more permanent artifact. The temporal nature of this form of practice offers the opportunity to move away from the traditional materials of painting or sculpture often chosen for their strength and stability for the future. Stone or oil paint tend to create immutable objects in a fixed or memorial space. In the twentieth century a new tradition evolved, using temporary materials or processes, sometimes even presenting their own decline. This is evident from auto destructive art (Metzger 1960s) to art practices that sit closer to time-based

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_9

events such as happenings (Kaprow 1960s). The use of film or video has allowed for documentation beyond the temporality of these works. This permits temporary artwork to evolve and sit alongside other time-based creative disciplines, such as theater, dance, and the screen.

In an age of easily replicable technology and digital documentation, photography, and video, including the new non-fungible token (NFT), the repetition of a live event or singular object is now possible. This offers re-presentation through time and place. In this way, repeat viewing can shift from an original encounter, into an ever-expanding range of settings, and across many timeframes. The digital format which can be accessed through the camera and screen, offers an alternative technological place. This has extended the possibility of the object beyond its materiality or time-limited contingency (however long). Objects contingent on time and space can now offer future influence, beyond the moment of their existence. This is made possible by digital means.

9.2 Case Study *Spoons*—Temporality, and Art Thinking

Spoons is a sculptural artwork that was created in the digital and analog worlds simultaneously (Fig. 9.1). The period of its existence as an object is transient. It is made to collapse and exist only in the moment of its multiple constructions. However, the video documentation of the very first collapse is always replicable, accessed through video documentation, and published online and periodically available in gallery exhibitions.

The sculpture consists of a large pyramid standing 2.5 m high. It is made from 9273 plastic spoons and 3091 rubber bands. The latticework of the pyramid is constructed by tessellating tripod shaped, repeated units, consisting of three plastic spoons tied together with a rubber band (Fig. 9.2).

The pyramid is delicately balanced, with each tripod unit offering structural support, all working to realize the complete form. However, over time the rubber bands that hold the tripods together rot and break, resulting in the whole sculpture experiencing a random decay. As the pyramid collapses, the materials return from components in a sculpture to the original plastic spoons and rubber (Figs. 9.3 and 9.4).

Originally created in 2008, the first material collapse was recorded with time-lapse video, capturing one frame every 20 min over four months. Each time the sculpture is rebuilt for exhibition this original video is shown alongside the newly formed pyramid. Presenting the digital documentation of a past event, alongside the analog present. This offers a comparison of differences over time. Viewers can read between the video documentation of the original collapse, and the live moment of a decaying sculpture. The formula for the creative object is always the same, the same number of spoons, the same number of rubber bands, the same process of construction, and yet the same event can never be replicated through time. Each presentation of collapse is different, and each creative moment is experienced differently.

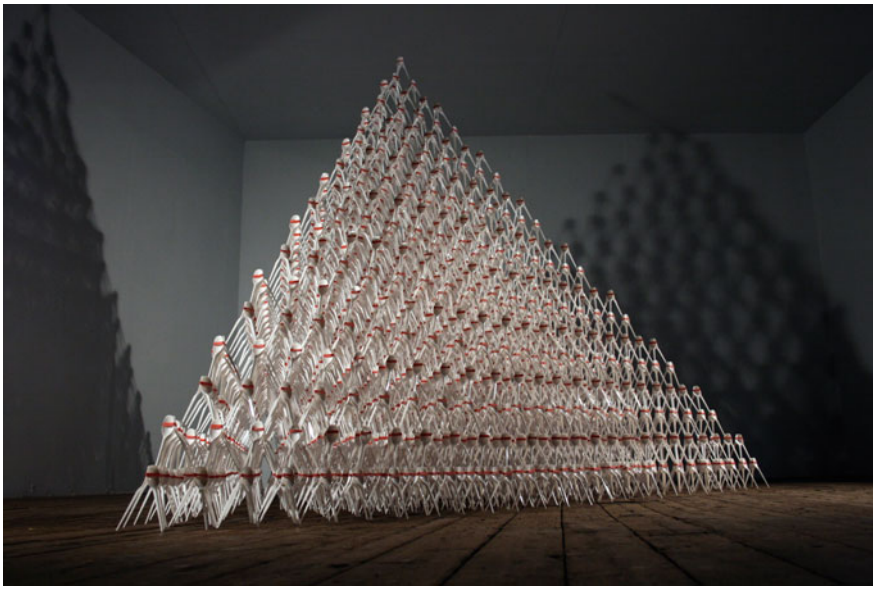

Fig. 9.1 Townsley J. *Spoons* Material 9273 plastic spoons and 3091 rubber bands (2008), copyright © Jill Townsley, reproduced with permissions

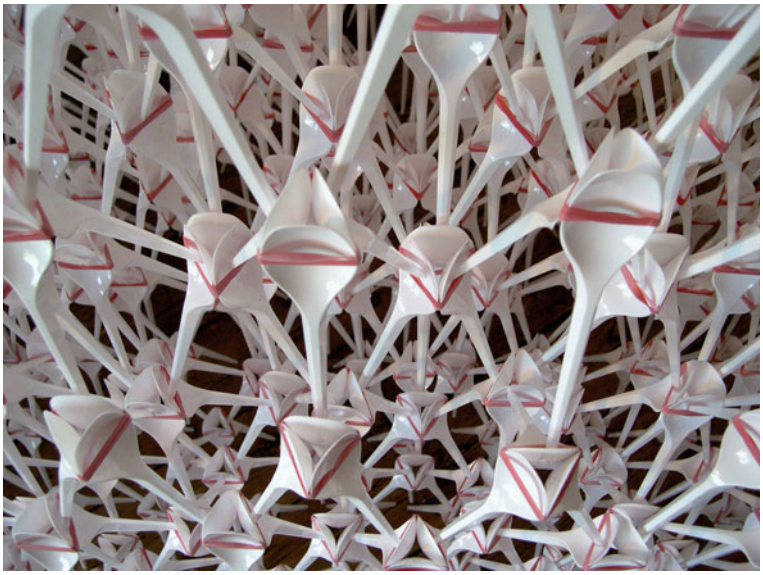

Fig. 9.2 Townsley J. *Spoons* Detail, copyright © Jill Townsley, reproduced permissions

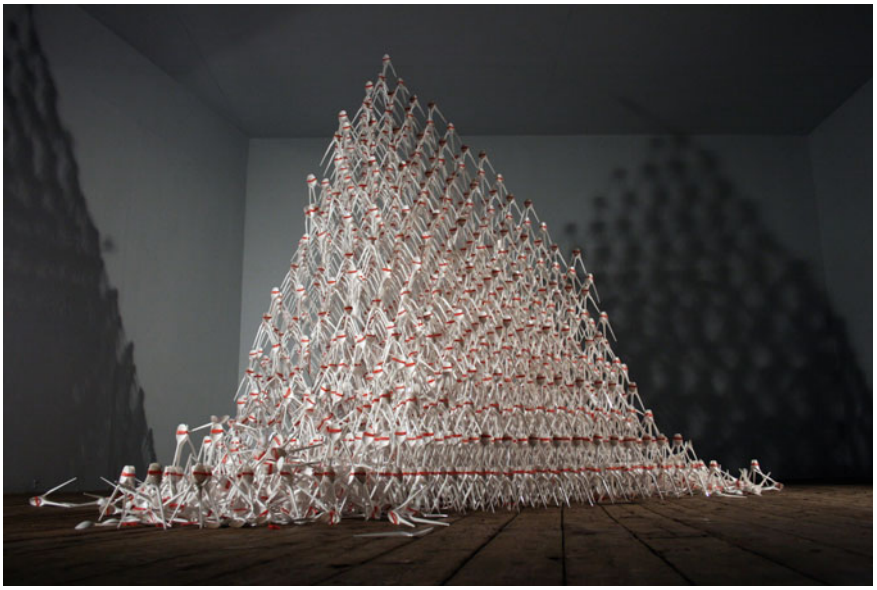

Fig. 9.3 Townsley J. *Spoons* still from video, copyright © Jill Townsley, reproduced permissions

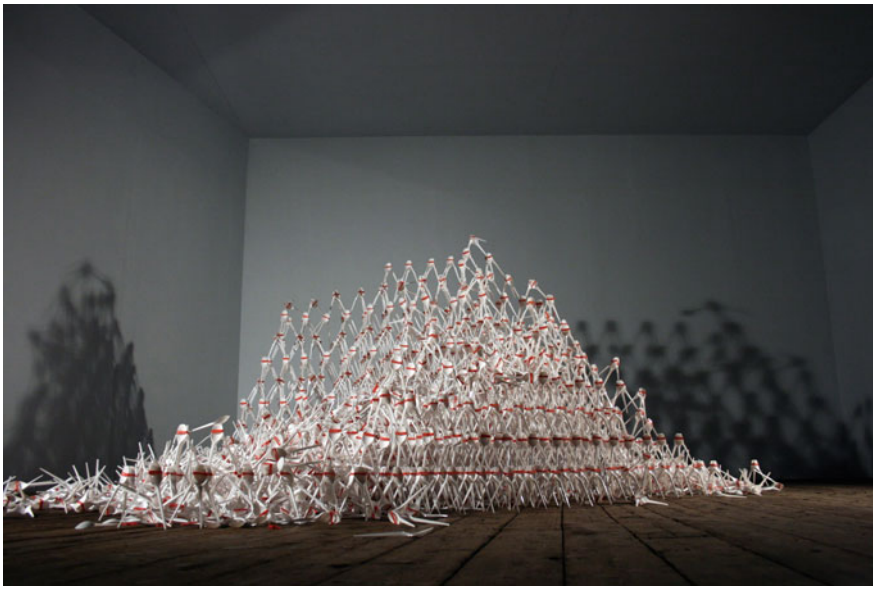

Fig. 9.4 Townsley J. *Spoons* still from video, copyright © Jill Townsley, reproduced with permissions

This difference is also accentuated by the different timeframes held within the digital and analog presentation. A hyper-real digital video can show a speeded-up collapse by presenting only one frame every 20 min, and also the real-time, slow collapse of the analog sculpture.

9.3 Art Thinking Meets Contextual Thinking in Time

To identify art thinking within *Spoons* we may, (though not exclusively) take directly from its material form. The materials themselves, multiple, mass-produced, low value plastic and rubber objects, have cultural currency beyond their original appropriation. They have obvious economic, and process reference, and for that reason have some influence over what may be considered a creative communication or meaning. The idea of meaning here is a difficult one, the object of art is not didactic. The artwork was not conceived as a place for a factual statement, but a space for creative discussion. The nature of that creative conversation is also never fixed, it is transient, existing in an ever-changing context through repeated reception, time, and the relational influence of any current cultural concerns of the viewer.

In 2008, during a time of economic collapse, *Spoons* featured within the context of the exhibition, Second Lives Remixing the Ordinary, at the opening of the Museum of Art and Design in New York. Along with other artifacts in this curated group exhibition it instigated discussions of process collapse, including Fordism, appropriation, reappropriation, and renewal. Over time and through later reconstructions, the meanings assigned to *Spoons* have changed and the contextual references have shifted, and the understandings are different.

Potential references for *Spoons* today capture more broadly the ecological dangers of cheap multiple plastic objects; from the toxicity of their production, to their microplastic influences on animal and plant eco-culture. The work is now exhibited in group exhibitions that specifically curate these concerns, e.g., *Plastic Matter* exhibition (2020) at the Art and Design Gallery, University of Hertfordshire. This curated exhibition emphasized that a link between our climate catastrophe and our means of production has become more collectively understood. Statistical evidence has consolidated our understanding of the negative environmental consequences of human production. Consequentially the work has drawn some equivalence between an increasing environmental context and the social relationship to mass produced goods, processes, and objects.

This new context also activates meaning for the random collapse of the pyramidal object, where comparisons can be drawn between the structural collapse and our own human footprint as transient, both individually, and collectively. This understanding is possible despite our culturally agreed understanding of the pyramid as a symbol of stability and longevity, contextually referenced through historic or memorial site (e.g., Egyptian pyramids) and the conceptually complete regular solid presented in mathematical theory.

These two implications for *Spoons,* compared across two group exhibitions in 2008 and 2020, offer distinctly different potential meaning, if indeed references can be identified as meaning? What is clear however, is that these two examples separated by time present creativity in relation to socially-based contextual and cultural concerns. Art thinking is prominent, but this work does not answer questions or fulfill fixed needs. Its influence is significant only through the type of creative cultural connections that Ogawa outlines [1]. Understanding is contextually referenced through critical thinking and reflection. For this reason, the references are transient, and meanings are always changing over time, through moments of encounter and reception, positioned relationally to each viewers individual context, and collective social concerns.

9.4 Creativity—Reception and Repetition

There is a wealth of philosophical documentation around reception theories, especially in relation to literary text, where the analysis of communication models provided a space for the readers creative interpretation. This needs to be acknowledged. Stuart Hall ascertained that ideas are'encoded' through text (and other means) then 'decoded' by the reader or receiver of the creative form.

> Traditionally, mass-communications research has conceptualized the process of communication in terms of a circulation circuit or loop. This model has been criticized for its linearity—sender/message/receiver—for its concentration on the level of message exchange and for the absence of a structured conception of the different moments as a complex structure of relations. But it is also possible (and useful) to think of this process in terms of a structure produced and sustained through the articulation of linked but distinctive moments—production, circulation, distribution/consumption, reproduction [2].

This understanding further indicates that the creative form is not fixed. Hall goes on to categorize how a text may be received, and outlines differences, through cultural profiling and collective cultural forces. An upload download model of creative communication can never produce a repeat of a singular original, as a 'loop'. Each viewer receives the information in a way particular to themselves, individual representation happens. The categories posited by Hall (the dominant, oppositional, or negotiated reading) offer a general way of thinking through this complex creative relation (between art object and viewer). This is a relational and creative communication no longer binary in form. The possibilities are infinite and in constant flux, due largely to the impossibility of repetition.

There are also questions arising when thinking about creative communication as a binary encode and download structure, despite an understanding that repetition can never offer a singular object or event. This model is much more aligned with design thinking, it is determinative and direct, it meets a need for stable communication. It remains untouched by aspects of transient cultural constructions of meaning reflecting human relational complexity.

9.5 The Digital Context and Repetition

In the digital space the terms encoding, and decoding have a much more concrete relation with repetition. Repetition is possible through the replication of the digital form, in perfect repeat (glitches aside) from one digital file to another, making the digital source much more constant through the process of repeatability. Meanwhile the variant of human reception, through re-presentation or repeat observation, is still always changing, always transient. Multiplicity as outlined by Hall is clearly operating, despite the digital space having more control over repetition. Offering the original repeatedly is still open to constant change through repeat reception over time.

The vast possibility of singular relational creative outcomes brought about through the multiplicity of reception, has some similarity to Walter Benjamin's theory of repetition [3] referring to the new technologies of print reproduction booming in the early nineteenth century. Benjamin observed the egalitarian and more general access to printed material, cutting through the strata of cultural privilege. However, he simultaneously lamented the lack of direct lines of communication from author to viewer (or reader) brought about through access to the original, the singular creative object. Benjamin perceived objects of creation, replicated in print, as changing their creative state. In the process they were undergoing a loss of 'aura', or closeness to the authors human creative origins, something only available through the singular object. In Benjamin's construct, something is lost or becomes less powerful, as it moves away from the singular source and the body of the artist, altered through technological repetition.

Digital replication is at source constant in a way that print could never be. But whether we are thinking about the replication of a printed image or a digital image, all become unstable in their communication with the analog world, through reception, this is always a creative space.

Multiplicity here becomes a tool of creative re-generation. In *Spoons* that multiplicity also operates in many ways; there is the multiplicity of the material, the process form of the structure, the multiple failures of the materials (rubber bands) that instigate a failure of the singular pyramidal form and its ultimate collapse. We also have structural failure operating across video and analog settings. However, with each collapse there is a regeneration, as the sculpture is rebuilt, or the video is looped. But finally, more powerful in its generative power is the communication between viewer and object, this never completes, but is always re-generative.

In *Spoons* all these repeated processes happen over time, material, reception, and in analog and digital spaces. All are opportunities for contextual reference toward identifying a creative meaning for this work. Meaning that is not static but changes in relation to repeat viewing, material state, and across the digital-analog divide, and referenced within a collective relational and cultural setting, resulting in multiple creative destinations.

9.6 Socialized Time

The idea that creativity can be collectively authored in culture, realized in permanent flux, ever-changing and ever-emerging, has some resonance with Henri Bergson's theory of *durée*: *"Bergson's culture is socialised time actualised in experienced duration or durée—culture is always in motion"* [4]. He argues against thinking about components quantitively, and advocates that change is experiential and intuitive, socialized time, experienced through the body, "*in social experience—in short an embodied conception of culture*" (ibid.).

> he argues for a view of time as qualitative; intuition as situated within experience rather than about it (ibid.).

Bergson also uses the material characteristics of an elastic band as a metaphor. He talks about an elastic band being stretched, as an illustration to interrogate what may be understood as duration.

> Bergson tells us first to contract the band to a mathematical point, which represents "the now" of our experience. Then, draw it out to make a line growing progressively longer. He warns us not to focus on the line but on the action which traces it. If we can focus on the action of tracing, then we can see that the movement — which is duration — is not only continuous and differentiating or heterogeneous, but also indivisible (ibid).

In the process of *Spoons* the breaks are literal, the rubber bands snap, causing the pyramid to collapse. This is perhaps equivalent to '*the now of our experience*'. This is the moment of 'snap'. However, it is the slow decay of the pyramid that better represents duration, the act of tracing from the complete pyramid to piles of spoons landing on the floor. Most importantly that duration is played out in different ways in the digital video, time speeded as one frame every 20 min into a condensed animation of time. A speeded-up simulacra of the real time slow duration decay of the analog sculpture.

While Bergson's visual metaphor has material reference with *Spoons*, through the rubber band, he is clear that for him no image can truly represent duration, "*An image is immobile, while duration is 'pure mobility'*" [5]. However, if we were to apply the concept of duration to the communication between *Spoons* and audience reception or experience, we are getting much closer to *durée*. There is an invisible space offered through encountering the art object, which could also be considered qualitative and descriptive of *pure mobility*.

> Let us take our mind off the space subtending the movement and concentrate solely on the movement itself, on the act of tension or extension, in short, on pure mobility. This time we shall have a more exact image of our development in duration [6].

The art object is offering interpretation through reception to the viewer and so forming a relational position within the complex cultural contexts positioned within a milieu of creative possibilities. Socialized time makes creative interpretations have mobility and duration beyond a fixed moment, allowing mobility of meaning to 'stretch' beyond any singular origin. Through reception the object is much more

broadly durational, as meanings shift through time and space. These encounters are relational, forming creative meaning through a culture that is always in motion.

9.7 Conclusion

Art thinking embodied in the art object is by its very nature positioned within a broader context, linking across multiple destinations and transformative through time, and situation. This may produce a transient object; capable of raising questions of life from within, always re-drawn through critical contextual reference to time in the present. The lack of focus on destination is positively habituated toward offering outcomes that are less totalitarian in reception or fixed in meaning. Allowing space for the viewer in visual art terms (listener in music terms et cetera) to complete the authorship through reception. This can result in a more diverse creative milieu, forming a creative space between origin and reception that can initiate and raise debate.

Creativity located in art thinking does not always mean that we are all nudged toward the same conclusion or even the same destination. Instead, creativity in art thinking can be inclusive and embrace complexity. Reflection through creative art thinking can identify differences in understanding or thought from within, enabling us to perceive ourselves as individual yet connected to a greater whole. In relational terms, creativity employed in art thinking is always subject to community, society, and context. The opportunity to question perceptive norms, or societal structures, even help identify self within a community, is adding to a relational understanding, across time, space, subject, and experience.

References

1. Ogawa, H.: Art Thinking. Ars Electronica Futures Lab. Electronic resource: https://ars.electronica.art/futurelab/en/research-art-thinking/
2. Hall, S.: Essay encoding/decoding (Chapter 10). In: Hall, S., Hobson, D., Lowe, A., Willis, P. (eds.) Culture, Media, Language Working Papers in Cultural Studies, 1972–79. First published 1980 by the Academic Division of Unwin Hyman (Publishers) Ltd. This New edition, p. 117, Routledge, Abingdon (1991)
3. Benjamin, W.: The Work of Art in the Age of Mechanical Reproduction (1935) [The Work of Art in the Age of Mechanical Reproduction: Walter Benjamin (Penguin Great Ideas) Mass Market Paperback, London (2008)]
4. Linstead, S., Mullarkey, J.: Time, creativity and culture: introducing Bergson. In: Culture and Organization. Routledge, Abingdon (2003), vol. 9, no. 1, p. 3
5. Bergson, H.: In Lawlor, L., Moulard-Leonard, V., Bergson, H., Zalta, E.N. (eds.) The Stanford Encyclopedia of Philosophy (Fall 2021 edn.). https://plato.stanford.edu/archives/fall2021/entries/bergson/
6. Bergson, H: The Creative Mind: An Introduction to Metaphysics. Dover Books on Western Philosophy (Andison, M.L., trans.) (2007) Republication of the work published by The Philosophical Library, New York (1946), p. 165

Chapter 10
How Can Art Assist Science and Technology?

Rae Earnshaw

Abstract Art and science both involve creation and imagination and have been closely linked from the beginning of civilization. Activities during the Egyptian Kingdoms and the Greek world in both art and science have been preserved and reflect substantial achievements in design, form, and esthetics. The systematization of knowledge resulted in divisions between the disciplines which has taken time to understand and resolve. The contribution of art to the computer age is exemplified in the role of the data visualization artist, who now assist in the extraction of meaningful results from very large data sets. Artists have also used these complex images for their own artworks and exhibitions.

Keywords Esthetic purpose · Imagination · Symbolic representation · Creativity · Data visualization · Data artist

10.1 Introduction

Art may be defined as follows:

> Art is generally understood as any activity or product done by people with a communicative or aesthetic purpose—something that expresses an idea, an emotion or, more generally, a world view. It is a component of culture, reflecting economic and social substrates in its design. It transmits ideas and values inherent in every culture across space and time. Its role changes through time, acquiring more of an aesthetic component here and a socio-educational function there [1].

Art involves "*involves creative or imaginative talent expressive of technical proficiency, beauty, emotional power, or conceptual ideas*" [2].

Science may be defined as:

> A systematic endeavor that builds and organizes knowledge in the form of testable explanations and predictions about the universe [3].

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_10

10.2 Developments in Art and Science

It is currently believed that scientific and engineering approaches to the natural world can be traced back to ancient Egypt and Mesopotamia around 3000–1200 BCE [3] and is analyzable in many of the buildings (such pyramids, temples, monuments, tombs) which were constructed at this time and are still visible today. Also evident from this era are the vast number of cave paintings and art and decorative work in mosaics on the walls of such constructions. It clearly reached high levels of accomplishment in painting and sculpture which showed the style and symbolic representations of the period, many of which have lasted 4000 years and can be seen today (Figs. 10.1 and 10.2) [4]. Mathematics, astronomy and medicine shaped Greek ideas when natural events in the world were analyzed in terms of cause and effect.

Fig. 10.1 The funerary mask of Tutankhamun, 18th-dynasty Ancient Egyptian Pharaoh. The *Mask of Tutankhamun*; c. 1327 BC; gold, glass and semi-precious stones; height: 54 cm (21 in); Egyptian Museum (Cairo). Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported, 2.5 Generic, 2.0 Generic and 1.0 Generic license

Fig. 10.2 Predynastic Collage. Artifacts of Egypt from the Prehistoric period, 4400–3100 BC: clockwise from top left: a Badarian ivory figurine, a Naqada jar, a Bat figurine, a cosmetic palette, a flint knife, and a diorite vase. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license

At the same time as these artworks and sculptures were being produced, the Egyptians were also constructing the pyramids (Fig. 10.3). In order to construct such a building, it was necessary to have a level and horizontal base, and also know the size and weight of the stone blocks and how they could be fitted together, along with any alignment with external objects they required. Understanding the functions of surveying would have been necessary to some degree in order to produce plans for the construction, as well as the scheduling of the work. The margin of error was very low at 0.07%. In addition, the Great Pyramid was aligned with the cardinal points of the compass (north, south, east and west) to an accuracy of one fifteenth of a degree.

Therefore, some of the fundamental elements of precision in science and engineering were known and understood at this time.

It is clear from these images that an understanding of the science and engineering aspects of construction were framed by design, form, and esthetics. It appears that art and science were working together in harmony, with each adding value to the other. They must have been magnificent constructions in their day. The outer layers of the pyramids have been removed since then, which has resulted in their coarser

Fig. 10.3 The Great Pyramid of Giza, constructed between c. 2580–2560 BC during the Old Kingdom period. Licensed under the Creative Commons Attribution 3.0 Unported license. Attribution: L-BBE

external appearance today, as in Fig. 10.3. The original casing stones are believed to be of white highly polished Tura limestone to reflect the sun's rays. These would have given a smooth slope to the outside of the pyramids in contrast to the stepped appearance we see today.

10.3 Interrelationship of Art and Science

It is clear that scientific and artistic views of the world have been intertwined throughout history, and perhaps more so than is generally accepted today. A gradual separation may be observed after the academy was established and early universities divided study into different disciplines where students had to specialize. It was not long before a degree of antipathy developed between the earlier disciplines such as logic, grammar and rhetoric, and those that came later on such science and engineering. These were deemed to be applied knowledge and of lesser value and priority than fundamental knowledge. However, the events of the Scientific Revolution in the sixteenth and seventeenth centuries revolutionized the understanding of the natural world by means of observation and experiment. It replaced the Greek view of nature that had held sway for 2000 years [5].

It was the advances in mathematics, physics, astronomy, biology and chemistry which transformed the views of society about the world. This led inevitably to the Industrial Revolution of the eighteenth and nineteenth centuries when this understanding of nature was able to be harnessed by means of the developments in steam power, water power, mechanization, manufacturing, the smelting of iron ore, and architectural innovations to house the new businesses. Transportation was transformed by these new sources of energy and power [6].

It is often thought that science progresses by observation, analysis, and reason, whereas art advances through imagination, expression, and emotion. However, both involve aspects of communication, whether to validate the results of science, or to display the artistic work. In addition, artistic expression and scientific discovery have a common basis in creativity, perseverance, and insight. Many leading scientists have also been practitioners in the arts such as Einstein, Pasteur, Morse, Heisenberg, Planck, and Sidhof [7–9].

Science may be subdivided into the formal sciences (such as logic and mathematics), natural sciences (such as physical science, earth science, and life science), and social sciences (such as the social and cultural aspects of human behavior). Applied sciences include engineering and medicine [10].

Art may be subdivided into the visual arts, literature, architecture, cinema, music, theater and dance. Interactive media may also be included in a wider definition of art [11, 12].

Both science and art are involved in creation. Science may produce a model or description of the natural world and then make deductions from it. Art may depict a world view, or imagine an object not yet created. Therefore, the work of scientists and artists involves creativity.

Einstein said:

> After a certain high level of technical skill is achieved, science and art tend to coalesce in aesthetics, plasticity, and form. The greatest scientists are always artists as well [13].

> The reason why art is necessary to science because creativity involves imagination, and imagination is visualization. Things we are able to conceptualize, visualize or imagine in our mind are the things we can also create, if we have the tools to do so. Oftentimes, some of the greatest discoveries in science involved using some form of art [14].

10.4 The Contribution of Art to the Computer

Artists and designers have contributed to the development of computers. Particularly notable are Apple products with their sleek design, esthetics, usability, and use of color. Apple's Mission Statement encapsulates the high priority they attach to these kind of attributes:

> Bringing the best user experience to its customers through innovative hardware, software and services [15].

Apple's vision statement is:

> We believe that we are on the face of the earth to make great products and that's not changing [15].

Artists have also used the computer to produce computer art (alternatively known as digital art). This can be any kind of image, multimedia, performance art, or gallery installation. The lines between traditional art and new media art have become blurred, as some artworks combine both of these components [16–18].

Computers can be used to produce realistic images for animations and films (e.g., Fig. 10.4). Artists often contribute to the design and manipulation of the graphics algorithms that produce such images—in order to obtain the overall style and form required.

Visualization Data Artists

Computers are increasingly being used to analyze very large data sets, often involving scientific information, or the results of simulations. In these situations, the only useful way to interpret the data is to use visualization tools to present images or animations on a display. Given that colors and scale often shape the way such images are interpreted, artists are often involved so that the images are presented in an optimum way. Artists can make the significance of the data visible [19–21].

Computer Art

Artists may also use such data and visualizations to produce artworks in their own right [22]. Such data has become an art form in its own right [23].

Fig. 10.4 A procedurally generated photorealistic landscape created with Terragen. This has been used in creating CGI for movies. Licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license

10.5 Contribution of Art and Design to Research and Development Projects

As summarized in the Chapter on 'Research and Development on Creativity' in this volume:

> Partnerships which have to deliver a product or service normally have partners with expertise in usability testing, user trials, human computer interaction, and art and design. In order for a product or service to be viable in the market-place it has to justify its existence and provide function, form, and value to the appropriate sector, as well as being able to appeal to potential users. This is where expertise in art and design can add value to the product. Such partners can add value in all areas of the EU's projects, not just in culture and creativity. This is where a consortium with interdisciplinary expertise is able to make significant contributions in Europe and also internationally.

10.6 Conclusions

The contributions of the arts to the sciences have now come almost full circle. From the remarkable artworks and sculptures over 4000 years ago, to the sophisticated images and visualizations produced on the current supercomputers, the power, imagination, and creativity of the artist is clear to see. New tools have been created for the artist to use and the scientist has benefited from the artist's creative input to assist in analyzing data in the form of images. Artists and scientists can work together in harmony once again.

References

1. https://www.smashingmagazine.com/2010/07/what-do-we-really-mean-by-art/
2. https://en.wikipedia.org/wiki/Art
3. https://en.wikipedia.org/wiki/Science
4. https://en.wikipedia.org/wiki/Art_of_ancient_Egypt
5. https://en.wikipedia.org/wiki/Scientific_Revolution
6. https://en.wikipedia.org/wiki/Industrial_Revolution
7. https://summerfieldwaldorf.org/the-greatest-scientists-are-artists/
8. https://news.artnet.com/art-world/artists-who-were-scientists-1821906
9. https://www.artsy.net/article/artsy-editorial-9-artists-made-contributions-science-leonardo-da-vinci-samuel-morse
10. https://en.wikipedia.org/wiki/Branches_of_science
11. https://www.eden-gallery.com/news/7-different-forms-of-art
12. https://en.wikipedia.org/wiki/Seven_arts
13. https://www.pbs.org/wgbh/nova/einstein/producer.html
14. https://www.forbes.com/sites/annapowers/2020/07/31/why-art-is-vital-to-the-study-of-science/
15. https://mission-statement.com/apple/
16. https://en.wikipedia.org/wiki/Computer_art
17. https://en.wikipedia.org/wiki/Digital_art
18. https://computer-arts-society.com/
19. https://www.britishcouncil.org/anyone-anywhere/explore/digital-creativity/telling-stories-numbers
20. https://www.printmag.com/information-design/top-five-data-visualization-artists-to-follow-on-instagram/
21. https://thecuriousprofessor.com/2019/12/14/visualizing-data-through-art-2/
22. https://www.theatlantic.com/entertainment/archive/2015/05/the-rise-of-the-data-artist/392399/
23. https://www.ted.com/playlists/201/art_from_data

Chapter 11
Research and Development in Creativity

Rae Earnshaw

Abstract The art and science of creativity and the creative process are examined. Analytic capabilities using information technology are supporting this work. Digital creativity is a focus for bringing together different disciplines, and also for providing support to the creative industries sector. The relationship between creativity and innovation is examined. National and international initiatives for research and development in creativity are presented. Many of these initiatives have funding programs which are seeking to investigate cognitive models of creativity using information technology, and also how creativity can be used to more effectively advance the research and development process. In addition, new tools are being developed to support creativity.

Keywords Creativity research · Cognitive models · Creative research · Digital industries · Cultural transformation · Innovation · Creative Europe · Knowledge transfer · Artistic analysis · Stages of creativity

11.1 Introduction

Many disciplines are seeking a greater understanding of creativity in order to be able to further research and development in their areas. Many national governments are investing in programs to improve the productivity of their work forces in order to overcome current problems and difficulties. Often this is perceived to be finding creative solutions to these problems leading to greater efficiency and effectiveness, and greater economic stability.

Four aspects to research and development in creativity are highlighted in this chapter. These may be summarized as follows:

1. The scientific and artistic analysis of creativity
2. Application of creativity to assist in research and development
3. Using creative approaches to advance interdisciplinary research and development
4. Creativity and innovation.

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_11

Scientific and Artistic Analysis of Creativity

This may be considered as research into creativity. How may it be defined? What kind of cognitive models lead to a greater understanding of its operation and applicability? Can context and environmental factors aid in its development and effectiveness? In such modeling, simulation, and analysis, information technology is often used to gather data and perform computations and visualizations. This aspect may be described as the scientific and artistic analysis of creativity.

Application of Creativity to Assist in Research and Development

The second aspect is to more fully understand how creativity may be used in research to advance knowledge and understanding in academic disciplines. What approaches can make creativity more effective at uncovering unknown information and knowledge?

Interdisciplinary Research and Development

This considers the question of how creative approaches may be used to advance interdisciplinary research and development (R&D). Many academic disciplines exist in silos due to the budget allocation mechanisms within the academy and the traditions within disciplines. How can these barriers be overcome by using creative strategies? New knowledge often arises at the boundaries between existing disciplines and it is therefore important to be able to benefit from this.

Creativity and Innovation

Creativity may be regarded as producing new and novel ideas, and innovation as seeking out ways to implement them. However, the boundary can become fuzzy when all partners are working together on a project.

Each of these aspects will now be considered in more detail.

11.2 Research into Creativity

Psychologist Mihalyi Csikszentmihalyi studied more than 90 men and women who possessed the following characteristics:

(1) they produced works that were publicly recognized as creative, and
(2) they influenced or affected their culture in some important way.

This led to the psychological concept of ‘flow’ [1], a highly focused mental state conducive to productivity [2–4]. It may be characterized by complete absorption in a particular task, and ability to focus intensely on seeking to understand the task.

Dietrich identified four types of creativity with corresponding brain activities as follows [5, 6]:

- Deliberate and cognitive creativity
- Deliberate and emotional creativity

- Spontaneous and cognitive creativity
- Spontaneous and emotional creativity.

Dietrich also summarized these as a deliberate mode, a spontaneous mode, and a flow mode [7].

Other researchers have also proposed various stages of creativity as follows [8]:

- Intention. Your idea is born
- Incubation. This is the time you begin to put thoughts together
- Investigation. Here is where you do research
- Composition. This is the DO part where you begin to compose
- Compose—Get it out
- Clarification
- Changes
- Completion.

Hennessey [9, 10] describes the Consensual Assessment Technique which enables a panel of experts to assess the degree of creativity inherent in a particular product. Although creativity may be difficult to define and characterize, many people are able identify it and recognize it when they see it.

Creativity and Intelligence

Research in creativity views creativity and intelligence as different attributes which most studies appear to show can only be weakly correlated at best, though other studies seek to show a relationship between creativity test scores and IQ scores [11–14].

11.3 The Application of Creativity to Assist in Research and Development

Epstein recommends [15]:

- **Capture your new ideas**. Keep an idea notebook or voice recorder with you, type in new thoughts on your laptop or write ideas down on a napkin.
- **Seek out challenging tasks**. Take on projects that don't necessarily have a solution—such as trying to figure out how to make your dog fly or how to build a perfect model of the brain. This causes old ideas to compete, which helps generate new ones.
- **Broaden your knowledge**. Take a class outside psychology or read journals in unrelated fields, suggests Epstein. This makes more diverse knowledge available for interconnection, he says, which is the basis for all creative thought. "Ask for permission to sit in on lectures for a class on twelfth century architecture and take notes," he suggests. "You'll do better in psychology and life if you broaden your knowledge."

- **Surround yourself with interesting things and people**. Regular dinners with diverse and interesting friends and a work space festooned with out-of-the-ordinary objects will help you develop more original ideas, Epstein says. You can also keep your thoughts lively by taking a trip to an art museum or attending an opera—anything that stimulates new thinking.

  The American Psychological Association states [16]:

  > A study last year in the *Creativity Research Journal* (Vol. 20, No. 1), found that working on these four areas enhances creativity. Seventy-four city employees from Orange County, Calif., participated in creativity training seminars consisting of games and exercises developed by Epstein to strengthen their proficiency in these four skill sets. Eight months later, the employees had increased their rate of new idea generation by 55 percent—a feat that led to more than $600,000 in new revenue and a savings of about $3.5 million through innovative cost reductions.

A number of funded research programs are seeking to identify how creativity can assist in various research areas.

Kelly provides guidance on developing creativity for research and those mentoring research [17]. This is based on a curriculum developed at the Hasso Plattner Institute of Design at Stanford University.

> By focusing attention on how research happens as well as its outputs, you can increase your ability to address research challenges and produce the outputs you care about. Simultaneously, you may also transform your emotional relationship with your work, replacing stress and a harsh inner critic with a more open and emotionally empowered attitude. Whatever your background, discipline, or career stage, this book can give you concrete tools to gain clarity, be innovative, and make progress in your research journey [17]
>
> In our work at the Stanford d.school, we've found that creative processes are useful to practitioners across many disciplines—design, business, and education to name a few. Through compelling, straightforward prose and concrete examples, this book shows that creative thinking is equally useful for researchers of all kinds. It is exciting to imagine the possibilities that will surely come from the approaches presented inside [17].

11.4 Using Creative Approaches to Advance Interdisciplinary Research and Development

A particularly significant gulf may exist between the sciences on the one hand and the arts and humanities on the other. When funding in the academy becomes constrained or limited, questions begin to be asked about how effective various disciplines are, and their overall benefit to society. This can set faculties in the academy in opposition to each other at the very time when more effective solutions may be found by a greater interworking. Snow characterized this as the two cultures [18]. This has been analyzed further in [19].

> This appeared to be due to a variety of factors including tradition, vocabulary, ways of working, and contributions to society, all of which could be different in different disciplines and circumstances. Critchley [20] proposed that Snow had diagnosed the emergence of

two cultures because of the loss of a common framework of understanding. Scientists and engineers favoured advancement of society through technology and industry, whereas the arts and humanities preferred intellectual and literary endeavor. However, Gould took an opposing point of view and emphasized the commonalities between science and the humanities [21]. In 1963, Snow appeared to take a more optimistic view about the relationship between science and the arts [19, 22]

In the Foreword to [19] Journeaux states:

In an interview with Alfred Appel Jr., in 1966, Vladimir Nabokov reacted to C.P. Snow's assertion that the gap between the two supposedly separate cultures of science and the arts was unbridgeable. He argued that science has an artistic and creative side and that the arts require scientific truths, saying: "*I certainly welcome the free exchange of terminology between any branch of science and any raceme of art. There is no science without fancy, and no art without facts*" [23].

Journeaux also wrote:

However, if we consider the processes and ambitions associated with creativity supposed differences between artists and scientists may become less distinct. Creativity theorist Mihaly Csikszentmihalyi reminds us that: "*creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a sociocultural context. It is systemic rather than an individual phenomena*" [2]. In his book *Creativity* Csikszentmihalyi argues that levels of creativity do not just depend upon creative individuals but are also affected by the willingness of domains and fields to recognise novel ideas and artefacts [2].

11.5 Creativity and Innovation

Creativity and innovation may be related but the former is primarily concerned with the generation of ideas (which may also be innovative) and the latter is more concerned with the applicability of the ideas and their expression in practical situations. This may involve changing the existing processes within a particular organization or system. For example, as products and services evolve through innovation, companies have to decide the optimum time to migrate to a new system or a new set of products while maintaining existing market share, and also being able to attract new customers as demands shift in the market-place [24].

11.6 Research Funding Which Includes Creativity

This section summarizes funding programs related to creativity in research and development in the European Union, Fraunhofer in Germany, the National Science Foundation in the USA, and the UK.

European Union—Creative Europe

A database of the all the projects is online and contains details of the projects and the results of those projects that have completed their work [25, 26].

Horizon Europe—Cluster 2: "Culture, Creativity and Inclusive Society"

Under Horizon Europe, the European Commission funds research and innovation projects for social, economic, technological and cultural transformations toward healthier democracies where cultural values are protected.

Horizon Europe is adopting a creativity theme in its funding of Cluster 2. The European Commission mobilized €158 million for four calls under Horizon Europe—Cluster 2: Culture, Creativity and Inclusive Society. The Cluster 2 calls opened in June 2021 and closed on the 7th of October. The European Research Executive Agency (REA) received 378 applications across the four calls. 51 projects were selected for funding in June 2022.

Partnerships which have to deliver a product or service normally have partners with expertise in usability testing, user trials, human computer interaction, and art and design. In order for a product or service to be viable in the market-place it has to justify its existence and provide function, form, and value to the appropriate sector, as well as being able to appeal to potential users. This is where expertise in art and design can add value to the product. Such partners can add value in all areas of the EU's projects, not just in culture and creativity. This is where a consortium with interdisciplinary expertise is able to make significant contributions in Europe and also internationally.

The EU wishes to ensure that the program of work enables the research and innovation to be transformative across businesses and society as a whole within the European Research Area (ERA).

> In order to address today's multiple challenges, ERA needs to accelerate the transitions, strengthen resilience to future crises, while sustaining its competitiveness. High quality results require sufficient levels of investments in R&I, in particular from Member States and the private sector. Lagging innovation ecosystems can hardly improve without intense cooperation between academia and industry accompanied by better access to excellent facilities and infrastructures. While overall the EU is already leading in research and scientific excellence, it needs to step up its support to breakthrough market-driven innovations that will underpin green digital Europe and will boost growth, job creation and competitiveness. Only an excellent and impactful R&I system, will offer attractive career paths for researchers, mutually favourable circulation of talents within the EU and increase attractiveness of the EU abroad [27, 28].

The next section details how EU funding of projects operates.

European Union (EU) Funding of Projects and Initiatives

The European funds various kinds of initiatives and projects, usually by evaluating proposals that respond to Calls at particular times that define the priorities of the Call, the areas it covers, and the funding available.

Research and development projects are intended to be collaborative and have been funded in the past through various Frameworks. Horizon 2020 and ran from 2014 to 2020 with a budget of approx. $80 billion [29].

Horizon Europe is the current EU research and innovation program. It has a budget of €95.5 billion and runs until 2027. More than 85% of the budget is to be allocated to collaborative projects.

> The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It supports creating and better dispersing of excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness and optimises investment impact within a strengthened European Research Area. Legal entities from the EU and associated countries can participate [30]

Project proposals normally consist of 3 or more partners from different EU member states [31]. It is expected that the partners have the necessary expertise in order to carry out the R&D detailed in the proposal. In practice, most consortia are typically 10–20 partners, but some can have 30 or more. Duration of the project can be 3–5 years. The contribution that each partner makes to the delivery of the project is defined in the project proposal and partners usually have complementary expertise. For example, the research organization (e.g., universities or research institutes) can provide the state of the art knowledge at the cutting edge of research, industrial companies can provide development and manufacturing of prototypes and sales and marketing, and telecommunication providers can provide expertise on network delivery. SMEs, and-users, and marketing agencies can provide specific expertise that is required by the project. Associate partners and sub-contractors with specific functions can also be involved in the project but are not signatories of the EU grant agreement. Participants from non-EU countries can also be partners in the consortium. If the project proposal is approved, their funding component is paid for by their particular country and not the EU. Following the UK's departure from the European Union, organizations based in the UK can no longer be partners in proposals. However, the UK is intending to be an associate to Horizon Europe. If this is not approved, then an associate partnership in a proposal may be possible.

The objective is for the project to deliver a program of work for the development of new assets, and new products and services that meet the needs of European and international markets. Each partner in the consortium is expected to add value and expertise to the project as a whole, so that the overall project is able to deliver more than the sum of its parts. Proposals normally also a define a Consortium Agreement which defines how any intellectual, or other assets, which are developed during the project are to be shared across the partnership during and after the conclusion of the project. Such Intellectual Property Rights (IPR) can include patents, trademarks, copyrights, and any prototypes that may be developed in the project. The project is led by a Project Co-ordinator who is normally someone with appropriate management and commercial experience.

Normally a proposal as expected to have an appropriate balance between academic institutions, private sector research and innovation, and end-user organizations. The EU regards businesses as the 'engine of innovation'. Therefore, being able to involve them in wider partnerships with complementary expertise should be able to significantly drive this process forward with greater efficiency and effectiveness [32].

Project proposals are reviewed by a panel of experts in the subject area(s) of the proposal call and then ranked. Generally, many more proposals are received than can be funded. For example, for the Horizon Europe Cluster: Culture, Creativity

and Inclusive Society, the European Research Executive Agency 378 applications in 2021 across 4 calls, and 51 projects were funded starting in 2022. This gives a success rate of about 1 in 7 [33].

In FP7, partners included:

- research groups at universities or research institutes;
- companies intending to innovate;
- SMEs (small and medium-sized enterprises) or their groupings;
- public administration;
- researchers (from early-stage to experienced);
- research infrastructures;
- civil society organizations;
- organizations and researchers from third countries and international organizations.

It can be difficult for those new to the process to find appropriate partners that will be able to work together effectively on a proposal, and then on the project itself, if the proposal is successful. Joining a network can help in understanding the expertise sets available in European organizations and industry. Networks of Excellence were initiated during the EU's FP6 program. They can also provide contacts of potential partners in other EU states. Generally, they have a large number of partners with cognate interests who met from time to time to share ideas, and promote seminars and conferences. It also enabled those who wished to produce a program of work to join together and develop a project proposal.

National governments are concerned that their investment in the academies can be seen by their populations to deliver societal and economic benefits. Therefore, universities are increasingly including relationships with industry and business in their mission statements, alongside teaching and research. For example, the UK has the Higher Education Innovation Fund (HEIF) to support knowledge transfer to industry. Its objective is to benefit the economy and society [34].

This updated agenda for many of the academies in Europe enables them to synchronize more closely with the requirements of the EU research and development programs.

Fraunhofer

The Fraunhofer organization in Germany supports 76 institutes in Germany which focus on different aspects of applied science. Many have close relationships with academic institutions in their geographical areas [35, 36].

European Research Council

The EU also provides funding for frontier research in any field through the European Research Council (ERC). The average success rate for applications is around 12%. The sole criterion for acceptance is excellence. There are no thematic priorities or geographical quotas.

> In the ERC Work Programme, the ERC Scientific Council earmarked €628 million for an estimated 407 Starting Grants in 2023. The ERC is now beginning the evaluation of the proposals. The projects selected for funding are planned to be announced in summer 2023 [37, 38].

EU work programs are monitored to evaluate their impact and effectiveness [39].

National Science Foundation

The objective of the CISE is to explore the synergies between creativity and information technology, science, engineering, and design research.

> Information technology is playing an increasing role in extending the capability of human creative thinking and problem solving. Design, as a reflective process, develops new products in the context of a perceived need or problem. In design, the reflection on problem finding becomes as important as problem solving, recognizing that designers often redefine the problem to be solved as they explore design solutions within a specific context. The combination of creativity and design thinking in information technology, science, and engineering has the potential to define new areas and lead to increased successful innovation. Considering the synergy of creativity with research in design can have outcomes such as new models of creative cognitive and computational processes [40].

One of the research areas seeks to understand creative cognition and computation:

> This area has two major thrusts: research and education. Research in this area leads to cognitive models that serve as inspiration for computational models of creativity, support for human creativity, and approaches for educating people to be more creative. This research is typically done by adopting or adapting a model of cognition and evaluating its creative performance in different contexts, or developing a new model of creativity based on empirical or ethnographic studies. The emphasis in this area is the development of new models of cognition and computation that explain or simulate creativity. These models may then become the basis for new tools and new educational environments [40].

Another area is to develop information technology to support creativity:

> This area both develops new software and user interfaces to support users in being more creative and evaluates their performance through user studies either in controlled environments with empirical studies or in the context of a complex problem or situation with ethnographic studies. The emphasis in this area is the development of new support tools where the tool itself may be a creative product, and the tool is intended to support people in their creative activities [40].

UK Arts and Humanities Research Program

The Arts and Humanities Research Council (AHRC) launched the Creative Industries Clusters Programme in 2018. The £120 million investment continues to drive innovation and growth across the UK's creative industries, to encourage a new type of applied research. It lasts from 2018 to 2023 [41, 42].

The AHRC also supplies funding to enhance the international impact of research related to the creative economy and global sustainable development [43, 44].

A complementary review of art and design examines how research and development in these areas can be formulated and framed and then evaluated and measured, particularly in terms of the quality of their research outputs [45].

11.7 Conclusions

Creativity is a hot topic with many researchers and national governments. The latter are concerned to devise methods and strategies to support businesses and national economies, and make them more internationally-leading and more resilient to problems and crises. Researchers are seeking to understand what makes creativity effective and how it can be optimized and harnessed to a greater degree. Funding programs in the areas summarized in this chapter are all seeking to obtain answers to these important questions.

References

1. https://en.wikipedia.org/wiki/Flow_(psychology)
2. Csikszentmihalyi, M.: Creativity: Flow and the Psychology of Discovery and Invention. Harper, New York (1996)
3. https://universalium.en-academic.com/98638/creativity
4. https://www.britannica.com/topic/creativity/Research-on-the-creative-process
5. Dietrich, A.: The cognitive neuroscience of creativity. Psychon. Bull. Rev. **6**, 1011–1026 (2004). https://doi.org/10.3758/bf03196731
6. https://www.linkedin.com/pulse/four-types-creativity-muhammad-faisal-rendi. 13 Oct 2017
7. Dietrich, A.: Types of creativity. Psychon. Bull. Rev. **1**, 1–12 (2019). https://doi.org/10.3758/s13423-018-1517-7
8. https://indieitpress.com/7-stages-of-the-creative-process-dreaming-and-doing/
9. Hennessey, B.A., et al.: Consensual Assessment. Encyclopaedia of Creativity, 2nd edn. (2011). https://www.sciencedirect.com/topics/psychology/creativity-research
10. https://www.sciencedirect.com/referencework/9780123750389/encyclopedia-of-creativity
11. Batey, M., Furnham, A.: Creativity, intelligence, and personality: a critical review of the scattered literature. Genet. Soc. Gen. Psychol. Monogr. **132**(4), 355–429 (2006). https://doi.org/10.3200/MONO.132.4.355-430
12. Benedek, M., Jauk, E., Sommer, M., Arendasy, M., Neubauer, A.C.: Intelligence, creativity, and cognitive control: the common and differential involvement of executive functions in intelligence and creativity. Intelligence **46**, 73–83 (2014). https://doi.org/10.1016/j.intell.2014.05.007
13. Kim, K.H.: Can only intelligent people be creative? A meta-analysis. J. Secondary Gifted Educ. **16**, 57–66 (2005). https://journals.sagepub.com; https://doi.org/10.4219/jsge-2005-473
14. Kim, K.H., Cramond, B., Van Tassel-Baska, J.: The relationship between creativity and intelligence. In: Kaufman, J.C., Sternberg, R.J. (eds.) The Cambridge Handbook of Creativity. Cambridge University Press, New York (2010), pp. 395–412. https://www.cambridge.org/core/books/cambridge-handbook-of-creativity/F0808D8443E6171BCBC6CAC470FC4EB7
15. Epstein, R.: The Big Book of Creativity Games. McGraw Hill, New York City (2000)
16. https://www.apa.org/gradpsych/2009/01/creativity
17. https://www.creativityinresearch.org/about-the-book
18. Snow, C.P.: The Two Cultures. Cambridge University Press, London (1959, 2001), p. 3.
19. Earnshaw, R.A., Liggett, S., Excell, P.S., Thalmann, D. (eds.) Chapter 20 in Technology, Design and the Arts—Challenges and Opportunities. Springer, Cham (2020), pp. 373–387. ISBN 978-3-030-42096-3. https://www.springer.com/gp/book/9783030420963
20. Critchley, S.: Continental Philosophy: A Very Short Introduction, p. 49. Oxford University Press, Oxford (2001)

21. Gould, S.J.: The Hedgehog, the Fox, and the Magister's Pox. Harmony Books, New York City (2003)
22. Snow, C.P.: The Two Cultures: And a Second Look: An Expanded Version of the Two Cultures and the Scientific Revolution. Cambridge University Press, Cambridge (1963)
23. Nabakov, V.: Strong Opinions. McGraw-Hill Book Company, New York (1973), pp. 78–79
24. https://weareive.org/what-is-the-difference-between-creativity-and-innovation/?ppc_keyword=creativity%20and%20innovation&gclid=EAIaIQobChMIhbPO2rWo-wIV8WDmCh3uVwUKEAAYAiAAEgJPB_D_BwE
25. https://ec.europa.eu/programmes/creative-europe/projects/ce-project-details/
26. https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/projects-results
27. https://op.europa.eu/en/publication-detail/-/publication/05f11ef8-288d-11eb-9d7e-01aa75ed71a1
28. https://op.europa.eu/en/publication-detail/-/publication/151f4fdc-2c97-11ec-bd8e-01aa75ed71a1/language-en/format-PDF/source-search
29. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en
30. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
31. https://www.ukri.org/apply-for-funding/horizon-europe/
32. https://publications.parliament.uk/pa/ld201213/ldselect/ldeucom/162/16208.htm
33. https://www.emdesk.com/horizon-2020-horizon-europe-basics-guide/horizon-europe-partnerships-building-winning-consortium
34. https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/higher-education-innovation-fund/
35. https://www.fraunhofer.de/en.html
36. https://en.wikipedia.org/wiki/Fraunhofer_Society
37. https://erc.europa.eu/news-events/news/applications-erc-starting-grants-2023-facts-and-figures
38. https://en.wikipedia.org/wiki/European_Research_Council
39. https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/evaluation-impact-assessment-and-monitoring/horizon-europe_en
40. https://www.nsf.gov/cise/funding/creativeit.jsp
41. https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/creative-industries-clusters-programme/
42. https://www.ukri.org/news/enter-the-metaverse-investment-into-uk-creative-industries/
43. https://www.ukri.org/opportunity/ahrc-follow-on-fund-creative-economy-for-sustainable-development/
44. https://unctad.org/topic/trade-analysis/creative-economy-programme/2021-year-of-the-creative-economy
45. Earnshaw, R.A.: Research and Development in Art, Design, and Creativity. Springer, Switzerland (2016). ISBN: 978-3-319-33004-4. http://www.springer.com/gb/book/9783319330044

Further Reading

46. DeHaan, R.L.: Teaching creative science thinking. Science **334**(6062), 1499–1500 (2011). https://doi.org/10.1126/science.1207918
47. Dyer, F., Martin, T.C.: Edison: His Life and Inventions. Harper and Brothers, NY (1910)
48. Franken, R.E.: Human Motivation, 3rd edn. Brooks/Cole Pub. Co. Pacific Grove, CA (1994)

49. Lehmann, J., Gaskins, B.: Learning scientific creativity from the arts. Palgrave Commun. **5**, 96 (2019). https://doi.org/10.1057/s41599-019-0308-8
50. Sawyer, R.K.: Explaining Creativity: The Science of Human Innovation, 2nd edn. Oxford University Press, New York (2012)
51. Sternberg, R.J., Grigorenko, E.L., Singer, J.L. (eds.): Creativity: From Potential to Realization. American Psychological Association, Washington, DC (2004)
52. Van Aken, K.: The critical role of creativity in research. MRS Bull. **41**(12), 934–938 (2016). https://doi.org/10.1557/mrs.2016.280

Chapter 12
Epilog

Rae Earnshaw

Abstract Various aspects of creativity are summarized. Some have known constraints and others have unknown constraints. The ways in which technology have been utilized in the creative process are summarized. Technology that offers the facility of interaction with the user enables iterative production of designs and creative works. The relationship between creativity, art, design, and technology is summarized in a set of propositions.

Keywords iPad paintbrush · Unconstrained creativity · Constrained creativity · Virtual environments · Connectivity · Internalizing images

12.1 Freedom to Create

Today's mixed interdisciplinary environments offer artists and designers significant opportunities to create new art forms and designs. They can also provide new ways of collaboration and connectivity which can be valuable for various kinds of creative works. In addition, multidisciplinary teams are able to share concepts and ideas over the network and work in the same design space via technology.

Each of the previous chapters contains a conclusions section which summarizes the main points in the chapter. It is not the purpose of this final chapter to repeat these conclusions, but rather to view the subject from a higher perspective. It seeks to understand why Leonardo da Vinci's creative ideas and drawings with regard to flight referred to in Chap. 1 took over 400 years to be realized in practice. This provides a relevant case study in seeking to understand the various elements of the relationship between creativity, art, design and technology.

12.2 Creativity Under Known Constraints

Painters may choose different brushes, or modify an existing brush, in order to achieve a particular effect in the artwork. Hockney was able to modify an iPad 'paint brush' with academic assistance in order to obtain the visual effect that he desired [1–3].

S. Liggett et al., *Creativity in Art, Design and Technology*, Springer Series on Cultural Computing, https://doi.org/10.1007/978-3-031-24869-6_12

The iPad also enabled the natural environment to be 'painted' more quickly so that various images could be produced for different times of the day.

> There is a fear that any artwork which utilizes technology, especially in a digital manner, creates a distance between the artist and their media, says Creed, 'but there is an accessibility to these prints because you can imagine how they were created. With Hockney's paintings so much of the process is hidden, but with the iPad there's much more evidence of mark making.' Almost paradoxically, Hockney's use of technology reveals the more tenuous human imperfections not found in his older acrylic works. It gives a window into how he moved his brush — or hand — across the tablet, through which we can clearly see the performative, gestural approach taken while creating these prints [4].

Proposition 1—Creativity and Computer Images

Where appropriate technology is utilized by an artist, the outcomes can be significant in their impact and value, as is evidenced by the iPad images produced by Hockney. This may be especially the case when these images are seen at a large scale in an exhibition. It is much more than a set of photographs and does allow the observer to internalize the experience of viewing the images.

Proposition 2—Creativity and Technology Dependencies

Some creative initiatives and outputs are reliant upon developments in the external environment. For example, it is unlikely that Hockney's iPad paintings would have been produced in their form and content without the prior development of the iPad.

Proposition 3—Creativity and Unexpected Outcomes

Developments in technology may not anticipate how they may be utilized in creative applications. Nevertheless, they can have unexpected advantages and benefits that may go far beyond the initial intentions of the technology.

12.3 Creativity Under Unknown Constraints

Three design scenarios are considered in this section. Their relationship to Leonardo da Vinci's drawings in the fifteenth century is explored. These drawings all had interesting and novel features but lacked a source of power or energy to enable them to function in the real world. Therefore, the constraints for their operation in the real world were not known or understood. Three sources of power are considered as follows:

- Steam engine
- Internal combustion engine
- Jet engine.

The first point to note is that prior to the Scientific Revolution (sixteenth to seventeenth centuries) it was not known how humans might be able to generate a flying machine. They had observed the flight of birds and deduced that heavier than air flight

should be possible [5]. By a recognition of natural laws and utilizing the processes of observation, analysis and experiment, it was possible to make more systematic progress in understanding nature and how its properties might be harnessed for the benefit of society.

Leonardo da Vinci in the 1480s had over 200 drawings and sketches that showed how he understood flight [6]. However, these did tend to concentrate on the flapping of wings, no doubt to mimic how birds appeared to fly. This illustrated the power of observation coupled with imagination and creativity. However, subsequently it was shown that these did not work in practice because they did not satisfy a number of design constraints which were not known until much later. These constraints were linked to a scientific understanding of the natural world.

Proposition 4—Creativity Under Unknown Constraints

In order for creativity to result in successful outcomes in particular practical situations, there is a need for an understanding of how it may be limited by the constraints inherent in those situations.

Prior to the Industrial Revolution (eighteenth to nineteenth centuries) it was not known how technology might change traditional practices because it had not yet been invented. The development of the steam engine during this period enabled significant amounts of power to be generated using natural resources (water and coal). However, containment and transmission of this power needed strong and heavy materials. They were used very successfully in engines for trains, cotton mills, and pumping stations. But they were far too heavy to be used in a flying machine.

However, the invention of the internal combustion engine in the nineteenth century using liquid fuel enabled the power to weight ratio to be significantly improved. Such engines were used in a variety of applications [5].

Between 1899 and 1905 the Wright brothers devised research and experiments that led to the first powered airplane in 1903 and a flying machine in 1905 [7].

The key design constraints that had to be understood were the design of the wings and also the speed of a fixed wing through the air that was needed to generate an appropriate amount of lift. Thus, although creativity had produced many ideas and designs prior to this, they did not work in practice until they also aligned with the physical laws to do with flight, and also the capabilities of industry to produce a design according to a specification.

Proposition 5—Creativity and Appropriate Use of Technology

There is an important relationship between creativity, design and technology. In order for the results of creativity to be harnessed in an optimum way, they need to synchronize with the requirements and limits of technology, and also the interfaces and designs necessary to utilize the technology successfully.

A further example is the design and development of the jet engine for airplanes by Whittle [8, 9] and others. It was capable of producing much more power than the internal combustion engine. However, because it was sufficiently different from the traditional internal combustion engine airplane with a propellor, the authorities in the UK were not sufficiently convinced to invest in it. This is an example of

where creativity allied with a correct understanding of science and technology was too advanced for the authorities to fully understand. Had it been recognized, the outcome of events at the time could have been completely different.

In a conversation with Whittle after the war, von Ohain stated:

> If you had been given the money you would have been six years ahead of us. If Hitler or Goering had heard that there is a man in England who flies 500 mph in a small experimental plane and that it is coming into development, it is likely that World War II would not have come into being [10].

Proposition 6—Creativity and Overcoming Difficulties

Some creative outputs are unable to reach their full potential if there is opposition within the society in which they are being created. In such cases, it could take months or years for such blockages to be overcome.

12.4 Creativity and Virtual Environments

Virtual environments can provide a 3D environment within which artists and designers can explore the use of different colors and materials [11]. Architects can try out different designs for buildings and explore how they fit into the surrounding environment, and also how they are perceived by people who walk within them. This can be very useful information to consider before they are built. Additional constraints such as the use of sustainable building materials, carbon footprint, and ecological factors can be incorporated into the project at the design stage.

It can be argued that a virtual environment is artificial and not a real-world environment. It is therefore only a representation of the real world. However, the output of an artist or a designer's building plans are also representations of the real-world. As such, it is simply a tool for artists and designers to use in any way they wish. It has been claimed that the use of technology can make it more difficult for the creator to establish an emotional connection with their creation. However, while this might be the case in a first application, successive uses will allow the creator to appreciate the opportunities and potential of the tool being used, just as the early painters adapted to the use of the paintbrush.

Such facilities can also support the use of audio and animations. These can add value to the visual image.

Proposition 7—Creativity and Virtual Environments

Virtual environments can offer new creative opportunities for artists and designers and enable them to immerse themselves more completely in various forms of representation and interact with them.

12.5 Conclusion

Science and technology may often be perceived as the primary drivers in a material world, resulting in the arts and humanities being forced into a more reactive position. However, when questions are asked about the values of the science, or the meaning that technological developments have uncovered, these disciplines are often at a loss. It may be regarded as 'beyond science'. This is where art can make a valuable contribution in being able to connect us with worlds outside science. At the same time, art practice has been forced by these developments to think of knowledge acquisition outside that of art alone. Therefore, all parties can be beneficiaries of collaboration and mutual understanding.

References

1. https://www.royalacademy.org.uk/article/article-david-hockney-ipad-painting-during-lockdown
2. https://200-percent.com/david-hockneys-ipad-drawings/
3. https://www.christies.com/features/david-hockneys-ipad-paintings-12116-1.aspx
4. https://en.wikipedia.org/wiki/Early_flying_machines
5. https://en.wikipedia.org/wiki/Internal_combustion_engine
6. https://sandiegoairandspace.org/collection/item/leonardo-da-vinci-ornithopter-mock-up
7. https://airandspace.si.edu/exhibitions/wright-brothers/online/fly/
8. https://en.wikipedia.org/wiki/Frank_Whittle
9. https://archivesearch.lib.cam.ac.uk/repositories/9/resources/1893
10. Conner, M., von Ohain, H.: Elegance in Flight, Reston. American Institute for Aeronautics and Astronautics, Inc., Virginia (2001)
11. Earnshaw, R.A.: A New Renaissance for Creativity in Technology and the Arts in the Context of Virtual Worlds. The Visual Computer (2021) https://doi.org/10.1007/s00371-021-02182-7. Open Access. https://link.springer.com/content/pdf; https://doi.org/10.1007/s00371-021-02182-7.pdf