CIRCUITS OF PRACTICE RESEARCH REPORT

NARRATING HISTORIES OF COMPUTING AND DIGITAL MEDIA IN MUSEUM ENVIRONMENTS

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INTRODUCTION

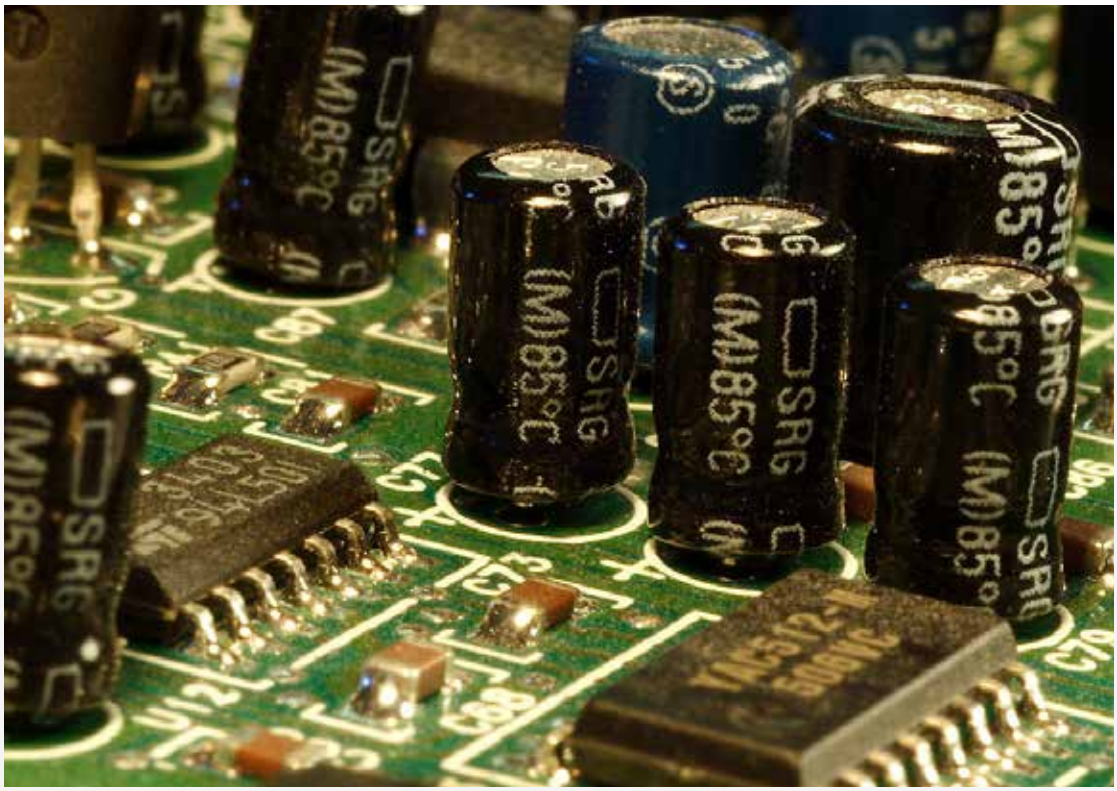
The Circuits of Practice project explores the construction and dissemination of narratives about histories of computing within museum environments. It interrogates how leading museums in the UK are helping to construct and disseminate historical narratives about computing through which the past, the present and the future of our societies are imagined and culturally constructed.

As computing technologies are ubiquitous in the everyday experience of billions of people around the world, histories of computing have become an important part of our historical heritage. Museums have the potential to play a key role in this context, facilitating the emergence of more diverse and deeper understandings of how computing contributed to shape the past, the present and the future of our societies. This is a particularly urgent task if one considers that narratives about technologies shape public debates that in turn inform the governance of these technologies.

In response to this challenge, the Circuits of Practice project has leveraged a plurality of approaches, theories and methods to conduct interdisciplinary practice-led research at the intersection of the fields of museum studies and media studies. Taking up the metaphor of the electronic circuit, where electrical connections between diverse components enable complex operations to be performed, the project aims at establishing a 'circuit' of practice-based, situated reflections through which museum-based and university-based researchers collaborate to address the following overarching question: how do museums narrate modern computing?

The project's research has brought together curators from leading museums in the UK (Bletchley Park, the Centre for Computing History, The National Museum of Computing, the National Science and Media Museum, the Science Museum, the Victoria & Albert Museum), leading international institutions (the Computer History Museum in the USA, the National Museum of Emerging Science and Innovation "Miraikan" in Japan, the Museo Nazionale Scienza e Tecnologia Leonardo Da Vinci in Milan, Italy), a company partner (BT Archives), and an interdisciplinary team of university-based researchers including Professor Simone Natale (Loughborough University and University of Turin), Professor Ross Parry (University of Leicester) and Dr Petrina Foti (Loughborough University).

The report presents the findings of a series of practice-based research workshops that constituted the bulk of Circuits of Practice's research. Each of the following sections of this report presents the findings of one of the project's three research groups, named "Circuits." The first report presents the findings of Circuit 1 "TIME," led by Ross Parry and involving two external partners: the Centre for Computing History and the National Science



and Media Museum. Circuit 1 addressed the following research question: How can museums narrate the development of computers through time? The second report presents the findings of Circuit 2 "OBJECTS," led by Simone Natale and involving three external partners: the National Museum of Computing, the Museo Nazionale Scienza e Tecnologia Leonardo da Vinci and Victoria & Albert Museum. This Circuit addressed the following research question: How can hardware and software artefacts be mobilized by museums to narrate histories of modern computing? Finally, the third report presents the findings of Circuit 3 "DATA," led by Petrina Foti and involving three external partners: Bletchley Park, the Science Museum, and the Computer History Museum. Circuit 3 addressed the following research question: How can museums narrate the role of information and data in computing histories?

The reports are the result of collective work conducted with the engagement of an exceptionally creative and insightful group of curators, researchers, practitioners and volunteers from our research partners. We would like to thank all people who contributed to this collective endeavor and that made Circuits of Practice a lively community even as the pandemic situation, through which the project was forced to adapt, moved most of our activities online. Our deepest thanks and gratitude go to everybody who contribute in some form to our research workshops and activities: Peronel Craddock (Bletchley Park), James Elder (BT Archives), Lisa McGerty (Centre for Computing History), David C. Brock, Dag Spicer, Hansen Hsu and Marc Weber (Computing History Museum), Simona Casonato, Francesca Olivini and Laura Ronzon (Museo Nazionale Scienza e Tecnologia Leonardo da Vinci), Geoff Belknap, Sarah Ledjmi and Phillip Roberts (National Science and Media Museum), Rachel Boon, Tilly Blyth and Elizabeth Bruton (Science Museum), Corinna Gardner, Natalie Kane and Juhee Park (Victoria & Albert Museum), Martin Campbell-Kelly and Mark Priestley (The National Museum of Computing), as well as our advisors Joshua Bell, Mar Hicks, Kimon Keramidas, Sabina Mihelj, Lara Ratnaraja, Kate Travers, and Maholo Uchida who contributed essential feedback to improve and develop this report.

Simone Natale, Ross Parry and Petrina Foti
February 2022

REPORT OF CIRCUIT 1 "TIME"

UNDERSTANDING THE TEMPORALITY OF HISTORIES OF COMPUTING IN MUSEUMS

Circuit lead: Ross Parry, University of Leicester

INTRODUCTION

The project's 'Circuit 1: Objects' has reflected upon the material and social dimensions that influence the changing meanings and positions that the objects of computing history might assume. Complementarily, 'Circuit 3: Data' has turned to the challenges and questions that confluence around the collecting and curating of 'data' as an artefact of computing history.

Tessellating with these approaches, the project's first 'Circuit' has taken yet another (perhaps contrasting) perspective – exploring the narrative scaffolding in both the living and the telling of narratives of computing history. And so, changing the research focus from the social and cultural nature of digital objects to the concurrently tangible and intangible nature of digital collections, this Circuit has looked instead to the logical structures within digital narratives themselves. To do so, this sub-group of research has turned to a fundamental concept. Indeed, an elementary and ontological idea that sits at the heart of all conceptions of history, formations of story, and experiences of narration: time.

This exploration of time as a structure for computing history has been led by the National Science and Media Museum (Bradford, UK) and the Centre for Computing History (Cambridge, UK). Both share previous and present challenges of curating histories of digital technology, be it one in the setting of a large, well-established, national multi-site UK museum funded directly by central government, the other within the context of a considerable smaller, younger, independent organisation. One with a remit that reaches across many aspects of the science of media, the other more tightly focused on interpreting specifically histories of personal computing. And so, as with its two companion 'Circuits', this is work that has been inherently practice-based – using past, current and planned work of the museum teams as a precinct in which to evidence, shape and challenge the project's ideas.

Over four months, three structured workshop sections, and surrounding activity, the Circuit 1 Partners sought to: *reflect* upon the key concepts supporting this investigation; *read* how these concepts are manifest (or are a way of understanding) the museums' existing provision; *respond* to these insights by identifying actionable outcomes for the future display of computing history at each site.

In Workshop 1 ('Reflect') partners set out to: identify (and build confidence with) the prominent dimensions of 'time' related to the display of computing history within museums, specifically: the development of technology; the historiography within interpretation; the temporality experienced by visitors; the maturity of institutional digital literacy; the notion of duration and entropy in philosophy and thought. Participants pre-read a set list of texts; over a 2-hour session these texts were used to identify a lexicon of key terms, a working framework of concepts, and a set of challenges and questions.

In Workshop 2 ('Read') partners attempted to apply the relevant concepts and critical frameworks identified from the first workshop to a 'reading' (a critical analysis) of an aspect of current public provision within their museum. This 'reading' was used to test the value of

the proposed concepts and frameworks for understanding constructions of time in museums exhibitions. The partners then agreed together which aspects of their museum's current or future/planned provision would warrant (and be strategically and/or operationally helpful for) further scrutiny within the third workshop.

In Workshop 3 ('Respond') each museum partner reported back on the substantive ways in which the workshops' insights around 'time' and 'narrative' had (and could) have an impact on existing and/or future interpretive and display approaches in their museums.

1. THEORETICAL FRAMEWORK

Underpinning the collaborative research of the 'Time' circuit has been a body of key theoretical works: on notions of time and the temporality of experiencing 'things' (Cavarero, 2000; Kopytoff, 1996; Domínguez Rubio 2016); on the role of chronology and teleology in history-making and historiography, particularly in the histories of technology and computing (Pihlainen, 2013; Natale 2016); on the time-based nature of visiting computer-based exhibits (Keramidas, 2015); and on the evolving context of disciplinary evolution (Kirshenblatt-Gimblett, 2004) and institutional maturity (Parry 2013).

This sensitising to a number of different 'dimensions' of time, and ways in which temporality plays a part in the structuring of computing history in museums, has allowed the Circuit to propose a working 'framework' that differentiates between what it posits as a series of individual 'latitudes' of time. This involves:

- **a 'technological' latitude** – where things are produced on time, developing beyond the museum in the market and society. This may involve the work of historians to document, unveil and organise in time different trajectories within histories of computing, as well as the work of different stakeholders, such as companies and governments, in orienting readings of technological development across time. Such readings and documentations might be picked up or relied upon in museum contexts.
- **a 'narratival' latitude** – where accounts are relayed using time, unfolding in the exhibit's interpretation. This involves, for instance, how an exhibit is presented as the "first" computer, thereby making an argument about primacy in time, or how different exhibits are presented as signing evolution or progress within a specific area of research or application.
- **an 'experiential' latitude** – where exhibits are visited in time, elapsing at the venue. This involves the practical situations through which museums exhibitions are experienced and perceived by visitors of the museums.
- **an 'organisational' latitude** – where practitioners are working through time, evolving in the institution. This involves the work of curators and other museum professionals, which happens over time, as well as the institutional history, identity and approach of a museum over time. For instance, in revising or proposing a new exhibition, curators might need to rely on previous work made by curators who worked at the institution at a different moment of its history. The organisational latitude is thus likely to inform the approach of everyone working in a museum as they develop "new" exhibitions on a particular topic or a particular phase in the history of computing.
- **an 'ontological' latitud**e – where life is time, our aging in the world. This refers to the relationship between the exhibitions and the biographical time of the people who visit or experience it. For instance, a person who visits an exhibition about 1980s videogame cultures may remember a device that she or he has owned, a game she or he has played; such memories will inform their interpretation and navigation of the exhibition.

What emerges is a way of recognising and identifying how notions and experiences of time are fundamental to the progression and sequential making of computer technology, the recounting and linear articulation of computer history, the duration and varied pacing of an exhibition event, the maturing practices and operational transformations of the museum, as well as the entropy and sensation of existence. At once the framework differentiates these distinct notions and roles of time within computing history exhibits, and yet conveys how inextricably bound to each other and inter-connected they always must be.

The distinction between different latitudes is meant as a tool to be used by museum curators, practitioners, and researchers for the planning, review and development of exhibitions about

histories of computing and digital media. Furthermore, this emerging Framework on the temporal dimension of computing history in the museum, can then provide the basis for a series of separate lines of enquiry and points of reflection. The Framework enables a series of separate questions related to time (and the temporal dimension to exhibition building and experience) to come into focus. In other words, equipped by the Framework, the practitioner and scholar alike are able to notice and are empowered to ask:

- (on technological time) how a computing history exhibit references a developing market and a progressing technological knowledge, and what assumptions that exhibit makes about these market and expert contexts, and how are they temporalized;
- (on narratival time) what use of tense the narrative structures of computer history exhibitions observe, what is past, present and future in these narratives, how are they related, and what status is given to each;
- (on experiential time) what explicit reference to (and implicit acknowledge of) computing history exhibits make to the duration and pacing of the visit event, whether the exhibit assumes a length of time for the visit experience, and where (and how) it controls that time;
- (on organisational time) how the computing history exhibit is a product of an earlier set of practices and a previous stage of knowledge for the museum, where the contrasts might be (in subject knowledge, in curatorial approach, in design treatments) between this display and other displays in the museum; and
- (on ontological time) how the computing history exhibit reference the inscribed life of people (as makers and consumers), and the stages, passing and historical period of these lives, and how the exhibit (explicitly or implicitly) acknowledge the life and lifespan of the visitor.

2. CASE STUDIES

2.1 'Life Online': National Science and Media Museum (Bradford, UK)

Workshops conducted with our partners at the National Science and Media Museum focused on the case study of 'Life Online', a pioneering exhibition dedicated to the social, technological and cultural impact of the web. The development of 'Life Online' stands, as revealed in this case study, as a reminder of how computing history in museums is always bound by the life of the museum – what Sarah Ledjmi (2020) the museum's Associate Curator of Sound and Vision) calls 'the long time of the museum, and the quick time of the people'.

Two of the museum-based researchers who participated to the Circuit workshops for the National Science and Media Museum contributed short commentaries that elaborated on how the latitudes workshop and the Circuits research has helped them reflect on their work and their museum's institutional culture.

Geoff Belknap, Head Curator, National Science and Media Museum (2021):

"The mission of the museum will always shape the histories it curates. Any history that a museum presents to its audiences can never be solely the product of a particular set of researched scholarly insights on the past. Nor can it be just the consequence of the collections available to that museum, and the particular stories and patterns that they might together evidence. In actuality, the history of computing the visitor encounters will always be shaped by that institution's own mission and strategic goals. The history experienced is, in other words, one that speaks as much to the organisational priorities of the museum itself, as it does to the historiographical decisions of its story-tellers. Computing histories in museums (like any histories in museums) are consequently, as a function of their institutional setting, mirrors of institutional stories. Inescapably, they become institutional histories.

> *In actuality, the history of computing the visitor encounters will always be shaped by that institution's own mission and strategic goals.*

This case study has explored this relationship between an institution's own development, and the evolving histories it then attempts to tell. Specifically, the work has explored this reframing of computer history through the locus of one case study institution – the National Science and Media Museum (Bradford, UK). Our research has followed the making of computer history across three distinct phases (and visions and identities) of this national museum. First in its guise as the 'National Museum of Photograph Film and Television', then as the 'National Media Museum', and the latterly within its current governance and identity as a national museum of 'Science and Media'. With each phase in the museum's recent history (over forty years), has come a retelling of computing history.

We're questioning why, as a museum that has photography, film, television and sound technology as its core collections, what does the internet and life online have to do with those collections and those narratives. Asking that question now is very different from asking it in 2008, because, at that point, we had a very different conception of what the museum was and what we wanted to do with ourselves and collections."

Phillip Roberts, Associate Curator of Photography and Photographic Technology, National Science and Media Museum (2020):

"The research has shown how as the role of 'media' and 'technology' is recalibrated within the museum's aims, so 'computing' and its history are likewise repositioned. In particular, our work has traced the reiteration of one exhibition ('Life Online'), showing how its evolution (between on-site and online instantiations, across different physical locations, proposed and actual, at different scales, with different narratives), reflect not just changing historiographical sensibilities, but the life of the museum.

[I]t is interesting reading the gallery back through the museum's expectations of itself. Though it feels like that gallery was born in a moment of time when the museum was more sure of the concept of media. Since then, it's changed the way that we think what media is. There's a sense that we've fallen back on those forms of media that are more easily embedded in material collections."

Seen against the Circuit's theoretical framework, the two commentaries provide a powerful demonstration of the key role that the organizational latitude of time plays in the construction, creation and development of exhibitions about computing at the partner institution. As the "Life Online" exhibition was scrutinized during the research workshop, it became evident that it was not possible to consider the unfolding of time in this exhibition by focusing on the technological latitude or the narratival latitudes alone, but it was necessary to delve into the history of the institution, i.e. the institutional latitude. The workshops, moreover, highlighted how different visitors and publics may project or contribute their own latitudes of time (which corresponds to the experiential and ontological latitude); these dimensions might be the subject of follow-on explorations that consider the visitor experience in particular regard with their experience of time.

3. CENTRE FOR COMPUTING HISTORY (CAMBRIDGE, UK)

The workshops conducted with this Circuit's second research partner, the Centre for Computing History, focused on the 'Convergence Wall', a display highlighting technological evolutions leading to the introduction of smartphones, and on developmental plan for 'Point and Click', a chronological display highlighting changes in Human-Computer Interaction. The following short commentary reflected on some of the issues that emerged in the workshops through the activation of the latitudes framework.

Lisa McGerty, Project Manager, Centre for Computing History (2020):

> "Exhibitions of computing history, like any exhibitions in museums, are productions. They require funding resource, professional capability and time. They are typically bound within the everyday contexts familiar to many organisations – of fund-raising, forward-p*lanning and stakeholder management. But they are also delivered within a complex production context distinctive to museums – of design processes, of installation schedules, of rights and permissions, conservation and security, promotion and programming. As such, the computing history exhibit, along with all museum exhibits (part performance, part publication, part product, part programmed event) are acts of public history-making ultimately constrained by the resources available to them.*
>
> *Likewise, for many new museums, where these resources may at first be modest, where the future of the institution is not certain, and (perhaps even) where the business model is not fixed, there can be tension between curatorial ambition and the priority to become a sustainable organisation. The choice of exhibition subject, of target audience, of interpretive approach can all too easily be driven by an operational expediency. To write a popular history. To tell an inviting story.*
>
> *It is to these organisational realities (of resource constraint and operational expediency) to which this case study has looked – recognising candidly that museum histories of computing are also shaped by institutional capacity and capability. Taking the example of the Centre for Computing History (CCH) in Cambridge, UK as its principles focus, the research has attempted to evidence candidly but critically the business factors that can influence curatorial and historiographical decisions.*

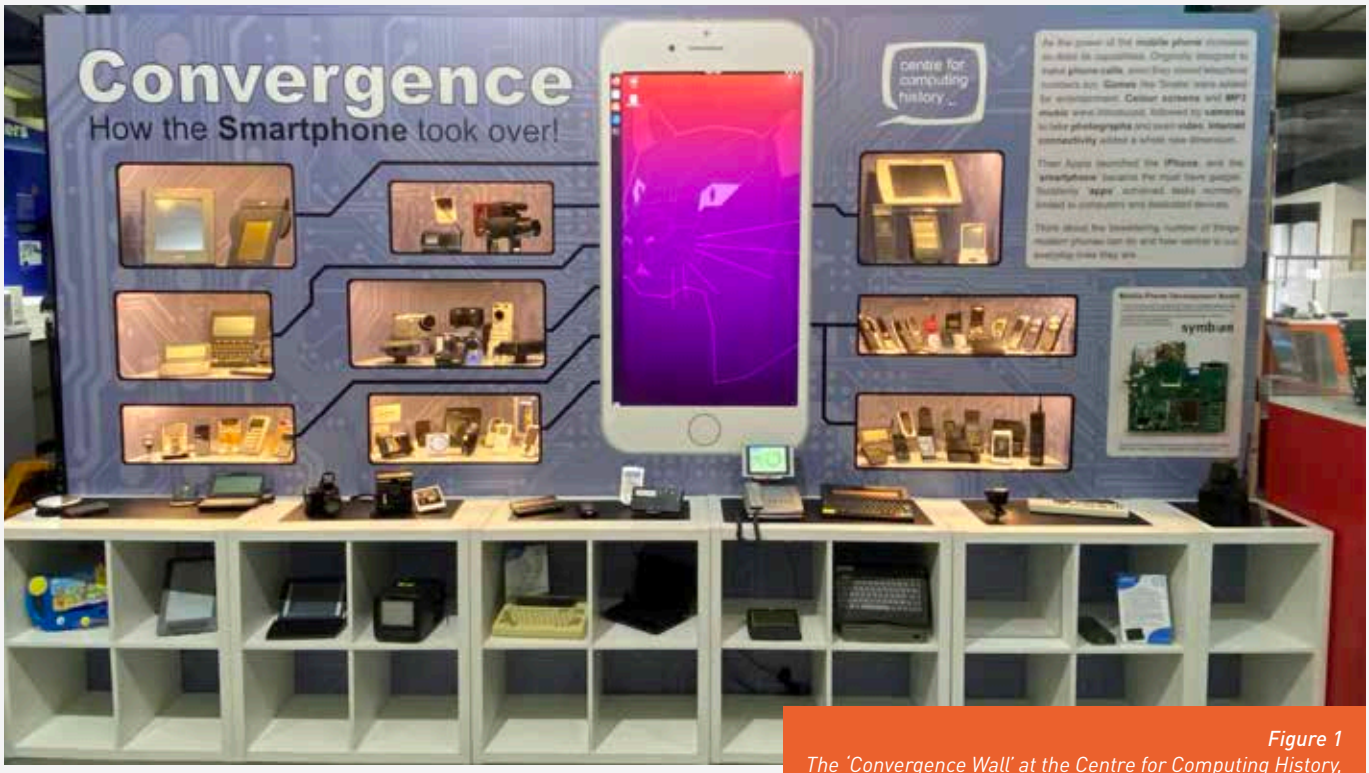


Figure 1
The 'Convergence Wall' at the Centre for Computing History, in Cambridge, England. Image courtesy: CCH

> *We are a young museum. So, the way we do things will be very different from someone who has been around fifty years more. I think we do things in the way we do, because we are as young as we are. We don't have the resources. We don't have the staff. We don't have the money. All of that actually has an impact on what we do as a museum. It can't not. How we fit with other museums and with* the concept of the museum in general is actually really quite important to understanding us as an institution and therefore what we do."

Seeing this museum 'growing up in public', the work has reflected upon the approach the Centre for Computing History has taken to presenting histories of computing to its visitors, and the decisions (business and curatorial) that informed these exhibits. Using some of the museum's key exhibits on video game history and on the history of the graphical user interface ('Point and Click'), what has emerged is a vivid account of how the narratives of computing on display in museums are also shaped by practical institutional constraints. This collaborative work corroborated and further extended reflections about how the unfolding of time in the museum context entails the establishment of complex relations between the technological, narrative and institutional latitudes.

More specifically, amidst a project (and set of three 'Circuits' and multiple case studies) where theories of narrative, questions of authenticity, and biographies of media are writ large, this case study reminds us of the role (and risk) played by organisational pragmatism in the public telling of computing history.

CONCLUSION

Similar to the material, social and narrative 'Dimensions' (identified by 'Circuit 2 Objects', see below the second section of the report) that provide a tool in which to trace the changing meanings of computing history objects, and much like the 'Matrix' (formed by the 'Circuit 3: Data', as described in the third section of this report) that is now allowing us to understand, to articulate, and then to develop further the varied contexts and experiences in which data are collected and curated by the museum within histories of computing, so this 'Framework' of temporal latitudes (developed by the project's 'Circuit 1: Time') is now offering us further means to focus and control our discussions around the making of computing history in the museum.

First, through this research, 'time' has emerged (intellectually) as a rewarding concept through which to enter and explore this subject of narrative building. And yet, beyond this conceptual help, it has also revealed itself (practically) to be a substantive component of the formation and experience of narratives themselves. That is, this work demonstrates how 'temporality' is a set of axes and 'latitudes' with which the subject of narrative and history building can rewardingly be segmented and interrogated, but – more fundamentally – that it is an essential component through which narrative is both assembled and understood. In other words, the notion of 'time' is not just useful, but is actually essential to our understanding and construction of museum narratives. Consequently, any future investigation into the building of museum narratives on the history of computing, would benefit from acknowledging the role of temporality, as well as developing a 'literacy of time' – as assembled and tested in this Circuit's proposed 'Latitudes'.

Second, this work evidences the inter-connectedness and co-contextuality between these multiple latitudes of time. Some of which perhaps are more obvious: such as between the technological latitude (the progression and sequential making of computer technology) and the narratival latitude (the recounting and linear articulation of computer history); or between this same narratival latitude and the experiential latitude (the duration and varied pacing of an exhibition event). However, some of the co-dependencies that emerged in the project's case studies were more revelatory: particularly those amongst the organisational latitude (the maturing practices and operational transformations of the museum), the narratival and experiential latitudes. These different temporal dimensions and types of time are not, in other words, discrete and exclusive. Rather they inform and frame each other – in what we might decide to call an 'ecology of time'. Consequently, for the 'Circuits of Practice' project more widely this suggests that any 'literacy of time' required and essential for future studies of exhibition narrative building, and the building of computing history in museums, will need to anticipate this co-contextuality. Consideration of any of these latitudes will always need at the very least awareness of (if not direct engagement with) the other latitudes.

The 'Time' circuit has begun to form a framework of temporality that might be of value to the shaping of any museum exhibition – not just of computing history. Where the 'beats of time' (and not just the more orthodox, and more readily comprehensible 'co-ordinates of space') enable extended approaches to exhibition design, as well as invite alternative readings of visitor experience.

Furthermore, our examination of the confidence and capability with computing in these displayed histories provides further insights to our understanding of the evolving postdigital museum – not least the self-reflexive ways in which the institution's on-going collecting and interpreting of digital technology (through these computing history exhibits) becomes an analogue of its growing digital maturity.

An additional, important element of reflection that emerged in the Circuit's research entails the relationship between the different latitudes of time and forms of bias that may be replicated, reinforced, or counteracted within museum exhibitions. For instance, work of women scientists or of scientists from minority backgrounds has been until very recently dramatically disregarded in the historical record and given less space in museum exhibitions. All evaluations of how exhibitions represent trajectories of development within the history of computing in museum environments should therefore take into consideration how potential technological and narrative latitudes could reproduce or disseminate historical, cultural and social bias.

> *Any future investigation into the building of museum narratives on the history of computing would benefit from acknowledging the role of temporality.*

REPORT OF CIRCUIT 2 "OBJECTS"

UNDERSTANDING DIGITAL OBJECTS IN MUSEUM ENVIRONMENTS

Circuit lead: Simone Natale, Loughborough University

INTRODUCTION

As digital media expanded into more and more facets of our everyday experience, the question of what digital objects are and how they are different from other kinds of objects has become of theoretical and practical relevance to many. Practitioners in different professional areas, public and private institutions, as well as users from the most diverse backgrounds, have been motivated and in some cases forced to consider how to treat and adapt their practices to new needs and problems posed by digital objects, such as hardware and software artefacts (Thylstrup, 2019). As new museums dedicated to histories of computing and digital media have emerged and many existing institutions integrated new histories of computing within their provision, such issues have been increasingly addressed within museum environments, too (Blyth, 2013; Weber, 2016; Foti, 2018).

Approaching digital objects, scholars have attempted to develop ontological definitions that aim at clarifying the "nature" of these objects (Hui, 2018; Kallinikos, Aaltonen and Marton, 2018). Others, however, have opted for a more flexible approach that interrogates not much what digital objects are in themselves, but rather the different ways in which people and groups make sense of them (Molloy, 2014). This Circuit report aims to contribute to these efforts by examining how digital objects are addressed in museum practice and how they are integrated into museum collections and exhibitions. Rather than providing a univocal definition of digital objects, our explorations overall show that digital objects cannot be defined or understood in absolute or ontological terms, but only through a situated and context-aware examination of the circuitry of meanings and relationships that digital objects establish within specific social environments, such as the museums. The case of museums, in this context, provides an ideal context to develop and test a more nuanced understanding of digital objects that acknowledge their flexible, contextual, and relational nature.

At different points across the last two centuries, museums have been forced to ask questions about what should be collected and preserved, and consequently, what counts as 'object' and where the boundaries between the tangible and the intangible can be drawn. The inclusion of objects related to the history of computing and digital objects in museum collections and exhibitions, in this sense, provides a double opportunity to researchers and practitioners. On the one hand, it can lead to new insights that help problematize and self-reflectively reshape existing practices and conventions within museum spaces (Foti, 2018). On the other hand, considering museums' relational, multi-faceted and interdisciplinary character, the case of museums has the potential to contribute to approaches that help tackle broader questions about digital objects – questions that are still to be fully answered and are all the more urgent to address in contemporary cultures (Hui, 2016).

Our Circuit conducted seven dedicated workshops that mobilized action research methods and design thinking methodologies. Three museum partners were involved in the workshops: The National Museum of Computing in Bletchley, UK, the Museo Nazionale Scienza

e Tecnologia Leonardo da Vinci (MUST) in Milan, Italy, and the Victoria and Albert Museum in London, UK. While the three institutions all include the preservation and exhibition of objects related to the history of computing and digital technology as part of their remit, they also offer different entry points to such histories and thus to digital objects – the first being dedicated specifically to the history of computing, the second more broadly to science and technology, and the third to arts and design. For each museum partner, we selected an object or a set of objects from the museum's collection that served as case studies to interrogate the role of digital objects in constructing histories of computing within museum environments.

The practice-based research conducted with our partners provided not just insight into museum practice but also, more broadly, an entry point into the social and cultural nature of digital objects. The museum functions, from this point of view, as a context in which meanings, uses, and definitions of digital objects are self-reflectively renegotiated, and a laboratory through which insights into the relational and contextual character of digital objects become manifest and transparent. As we developed our collaborative research, in fact, it became clear that no single answer could be provided to questions about the "nature" of digital objects. The digital objects under exam revealed to be not singular but plural entities, whose values emerge in relationship to the particular spatial and organisational contexts in which they were framed, and the specific social, discursive, and affective meanings that people – including curators, volunteers, and visitors – project onto them.

This report was redacted by Circuit 2's research lead, Simone Natale, but was the result of collective reflections and efforts of the other Circuit participants. These included research partners Martin Campbell-Kelly and Mark Priestley (The National Museum of Computing), Simona Casonato (MUST), Corinna Gardner, Natalie Kane and Juhee Park (Victoria and Albert Museum), as well as the other members of the Circuit of Practice university-based research team, Petrina Foti (Loughborough University) and Ross Parry (University of Leicester). Additionally, Laura Ronzon and Francesca Olivini (MUST) and Roberta Spada (Politecnico di Milano and MUST) participated and contribute to one or more research workshops.

1. THEORETICAL FRAMEWORK: THREE DIMENSIONS IN SEARCH OF AN OBJECT

The question of how digital objects can be described and understood has recently stimulated lively discussions in the humanities and social sciences. Although scholars have long demonstrated that software and data bear their own materiality and that rigid divisions between hardware and software fail to capture the complexity of the issue (Kirschenbaum, 2008), one of the key problems debated in the literature is the distinction between software and hardware artefacts (Hui, 2016). Another key issue is the role of interactivity (Manovich, 2002) and the situated character of digital media (Suchman, 2007), which suggest that digital objects can only be interrogated and understood within specific contexts and situations (Lesage, 2016). Finally, the plurality of media, systems, and dynamics that underpin the circulation of digital objects have attracted significant attention (Burrell, 2016).

A useful starting point, in this context, concerns the question about the alleged exceptionality of digital objects. Both the academic and the popular literature about digital media has tended to emphasize their novelty and peculiarity (Mosco, 2004). While it is undeniable that the emergence of digital technologies profoundly impacted contemporary societies, however, much can be learned by historizing digital media within longer media histories and by examining non-digital objects that pose similar sets of questions and problems (Marvin, 1988). In order to build theoretical and analytical tools to be implemented in the practice-based research phase, our circuit therefore broadened its perspective beyond the specificity of the digital, considering a set of approaches that examine other kinds of objects and artefacts from anthropological, sociological, and historical perspectives. Overall, the plurality of these approaches serves as a useful reminder that objects cannot be examined from a univocal and fixed perspective, but should be understood through a combination of complementary points of view.

A review of literature led us to identify three key dimensions that we considered relevant and valuable to our analysis: the material dimension, the social dimension, and the discursive dimension. The first dimension encompasses the materiality of digital objects.

As Domínguez Rubio (2016) underlines, any consideration of objects and artefacts should pass through the acknowledgement that things are subject to material processes that unfold over time. It is impossible to understand objects without a consideration of their fragile and temporal realities (Bell and Geismar, 2009; Ingold, 2012). At the same time, the materiality of artefacts such as digital objects cannot be strictly separated from their technical nature, which should be considered as integral to their material dimension (Link, 2011).

The second dimension concerns the social life of digital objects. A crucial tradition of thought in anthropology and in art theory has shown that things, like people, have a social life (Appadurai, 1986; Gell, 1998). In Gell's own words, "social agency can be exercised relative to 'things' and social agency can be exercised by 'things' (and also animals)" (Gell, 1998, pp. 17-18); therefore, artifacts can appear as agents in particular social situations. The meaning of objects, including digital objects, is continually renegotiated within a process that informs their social status as well as their material circulation (Lesage, 2016).[1]

The third and final dimension has to do with the fact that objects also have discursive lives: they are not only material things but also things that people perceive, imagine and talk about. Societies and individuals attribute ideas, appreciations, values to specific objects at particular moments of time. This level of the discourse is not irrelevant to understand objects' trajectories, since it informs how people, but also groups and institutions, approach and interact with them (Reynolds, 2018). If anything, this dimension is particularly relevant to digital objects, due to the degree of technical opacity that often characterizes digital objects. Since the functioning of hardware and software artefacts remains obscure to many, the narratives that circulate in the public sphere about digital objects play a strong role in directing their representation as well as their pragmatic uses: think, for instance, of the narratives and constant controversies about AI technologies and how they inform users' engagement with these technologies (Natale, 2019).

It is important to underline that the three dimensions, when it comes to examining specific objects and artefacts, cannot be treated as separated or distinct. All digital objects have material, social and discursive "lives," and the relationship between the three dimensions is subject to constant transformations and modifications across time. The advantage of considering these three dimensions, therefore, is that it helps acknowledge the dynamic character of digital objects – the fact, in other word, that digital objects cannot be defined or described in univocal or fixed ways, but need to be examined and understood against complex social, material and discursive environments.

Rosemary Joyce and Susan Gillespie (2015) have criticized the use of the "life" metaphor to consider material objects, contending that such notion replicates cultural bias that project the dynamics of human lives (e.g. birth, death, etc.) into objects, and proposing to use instead the more neutral notion of "itineraries." While we believe this argument is right, the idea that things have "lives" and even "biographies" (Natale, 2016) is helpful precisely because it helps to acknowledge and critically examine how our own projections and bias shape the ways material objects are perceived, understood and narrated across time. Things are inseparable from the social and cultural values that people attach onto them; acknowledging their "lives" and "biographies" from this point of view may help to illuminate the trajectories that shape our perception, representation, and engagement with material objects.

In the seven research workshops held within Circuit 2 during the research phase, the museum environments functioned as a space where to test and refine this working framework. The material and technical dimensions emerged, for instance, in discussions about the technical challenges of preserving digital objects, both

[1] *In terms of cultural heritage, the implications of this approach resonate in discussions about the close relationship between material artefacts and "intangible" heritage; see, among others, Kirshenblatt-Gimblett (2004); Rosner (2018).*

hardware and software, and about the different spaces in which objects were stored, exhibited and preserved. The social dimension entailed discussing how objects change uses and definitions across time and how they become a key component of people's lives, both before and after they are acquired by museums. Within the museum, in particular, digital objects enter a "circuit" of social relationships comprising museum staff and volunteers, visitors, as well as the other objects of the collections and the institutional structures (Parry, 2010). Finally, the narrative dimension was deemed crucial since the act of curating an object for exhibition in a museum also entails the development of specific messages and narratives through which such object can be presented to visitors, and through which it informs broader narratives in the exhibition space (Natale, 2016).

2. FOR A COMMUNITY OF MACHINES: THE HARWELL DEKATRON AT THE NATIONAL MUSEUM OF COMPUTING

The first case study selected was the Harwell Dekatron, also known as WITCH, an early relay-based computer now exhibited at The National Museum of Computing (TNMoC). This exhibit was considered an ideal case study for several reasons. First, the long history of the Harwell Dekatron, from its original installation at the Atomic Energy Research Establishment (AERE) in 1952 to its recent restoration, provided an ideal trajectory to examine the different dimensions of digital objects across time. Second, the computer is representative of key strengths in TNMoC's collection – both in historical terms, considering the significance of the museum's collection on the history of

Figure 2
The WITCH (Harwell Dekatron) computer under restoration at the National Museum of Computing, Bletchley Park, 2010. Image courtesy: Wikipedia Commons

early computing in Britain, as well as in terms of museum practice, since the Dekatron is one of several fully functioning exhibits that have been restored thanks to the efforts of the museum's lively community of technically skilled volunteers. Third, the Harwell Dekatron complemented very well work conducted on the other two case studies, having been developed in a period when the distinction between hardware and software was not fully relevant and computers were not yet mass-produced or "personal" devices (Ceruzzi, 2003).

The original function of the Harwell Dekatron was to perform computation for the AERE's research division and to act as a testbed for new instrumentation. After only a few years, however, new machines had been acquired by the research facility and researchers were doing little use of the Dekatron; this convinced AERE to do away of the computer. Thanks to the effort of one mathematician at AERE, John Hammersley, the computer was saved from dismantlement and repurposed for educational use. In 1957, the Harwell Dekatron was thus acquired by the Wolverhampton and Staffordshire College of Technology, where it was used as a teaching tool until 1973. The 1970s signed the beginning of a new life as museum exhibit for the Harwell Dekatron. The Birmingham Museum of Science and Industry added it to its collection in 1975, where it stayed until the museum's closure in 1997. Thanks to the initiative of a team of volunteers from the Computer Conservation Society, the Harwell Dekatron was finally moved to TNMoC's premises in 2009, when a new restoration began (Murrell and Holroyd, 2013).

As it emerged during the research workshops, one of the most notable characteristics of the Harwell Dekatron is the fact that the machine had not one but several "lives" as it moved from a research facility to an educational institution and finally to museum galleries.[2]

Such longevity can be partially explained at a technical level, since reliability was one of the key qualities of the computer: while the Harwell Dekatron, even at the point of its creation, was slow in comparison with other computers of the time, the machine was able to perform computation steadily and with very low incidence of malfunction or damage (Murrell and Holroyd, 2013). This played a role in the Harwell Dekatron's capacity to survive disuse and to be repurposed in different contexts. At the same time, however, its longevity cannot be explained by considering the technical dimension alone. There were several moments in the history of this machine when people who had developed an interest and an attachment to the machine saved it from being disassembled – from the efforts of John Hammersley at AERE in the 1950s to the team of researchers who completed its restoration in 2012. This shows the importance of the social dimension in explaining the longevity of the Harwell Dekatron. The discursive dimension also played an interesting and important role: in 1973, the machine was recognized in the Guinness Book of Records as "the world's most durable computer," which contributed to the rationale for its inclusion in the collection of the Birmingham museum. This pattern repeated three decades later: at the moment of its restoration and exhibition at TNMoC, the Harwell Dekatron was again listed in the Guinness World Records, this time as the world's oldest original, working specimen of a digital computer (The National Museum of Computing, 2021).[3] The specific narratives through which the Dekatron was presented and narrated, therefore, also laid the ground to its durability, functioning as a justification for the work involved in keeping and restoring it.

[2] As explained above, the concept of "life" is employed mainly in a metaphorical fashion, to account for the changing meanings and positions that objects assume across time and to the close interrelationship between the trajectory of objects and the experiences of people – which for digital objects include technologists, users, as well as curators and museum professionals – who interact and project sense onto them.

[3] The multiple "lives" of the Harwell Dekatron help serve as a powerful reminder that, as historians of technology have shown, obsolescence should be understood not in absolute terms but always at a circumstantial level, as the result of specific technological, social and cultural circumstances and decisions (Lipartito, 2003; Gooday, 1998; see also Natale, 2016).

The intertwining of technical, social and discursive dimensions in the history of the Harwell Dekatron was a consistent finding of the analysis, confirming that neither of these dimensions can be examined in isolation from the others. Another important technical characteristic, in this regard, was the computer's transparency: the fact that the particular hardware configuration of the Harwell Dekatron made it easier to see and locate all its components easily. This was instrumental in directing social and discursive uses of the computer as it was repurposed for educational and exhibition purposes.[4]

In the present day, the fully functioning, restored Harwell Dekatron is a heritage object that helps curators, volunteers and researchers to present key narratives about histories of computing to visitors of TNMoC. Its "meaning" as an exhibition piece, however, can only be understood within the wider context in which it is inserted. One first important element is TNMoC's institutional culture (Parry, 2010). This museum, in comparison with other institutions that likewise collect and display histories of computing, is characterized by a particular emphasis on technical aspects and features, reflected by the framing of the Harwell Dekatron as well as of other pieces from its collection (Marston and Wolfer, 2017). This, however, does not mean that the technical dimension is preponderant in the display of this computer. The technical features of the Harwell Dekatron become meaningful only as they are activated and foregrounded by the expertise and the emotional engagement of the lively group of volunteers that made the restoration possible and, contributing to guide tours and curatorial practice, animate the museum. If, as argued by Agar (1998), replica and restored specimens of early computer provide access to the "spirit" of the original machines, the example of the Harwell Dekatron shows that this spirit is not to be found in the machine's materiality per se but rather in the ways in which such materiality is inserted within the social environment of the museum. The Harwell Dekatron, in this regard, acts as a powerful communication medium through which the experiences and emotions of the museum's staff and volunteers are shared and recreated for the visitors of the museum (Burton, 2013).

Furthermore, like all other exhibits, the Harwell Dekatron becomes meaningful in the context of the broader exhibition at TNMoC: it is located, for example, in a room where there are several machines testifying of the pioneering period in digital computing, such as the EDSAC and the HEC. The object's meanings only emerges as part of a wider "community of machines," to use an expression proposed by TNMoC's Mark Priestley during one of the research workshops.

What does the Harwell Dekatron ultimately tell us about the nature of digital objects? Overall, the analysis conducted through the research workshops made clear that it is impossible to reply to the question about what digital objects are in absolute terms. The Harwell Dekatron does not have a "nature" on its own; instead, its meanings emerge in relationship to the network of material, social and discursive relations in which it is framed. This applies not only to the machine's present "life" as a TNMoC's exhibit, but to its wider historical trajectory as well. As we have shown, in fact, the different turns in the machine's history were characterized by similar interaction of social and material relations: for instance, the computer became obsolete due to the acquisition of other equipment at AERE and was saved from dismantlement thanks to the efforts of a researcher who had developed an affective attachment to the machine. The relational and processual nature of the Harwell Dekatron, in this regard, underpins not only its insertion within TNMoC's exhibition, but characterizes more broadly all the different configurations activated by its material, social and discursive dimensions throughout its history.

[4] *It is interesting to not that the Harwell Dekatron's transparency contrasts with the usual characterization of digital media as "black boxes" (Bucher, 2018); see also Foti (2018).*

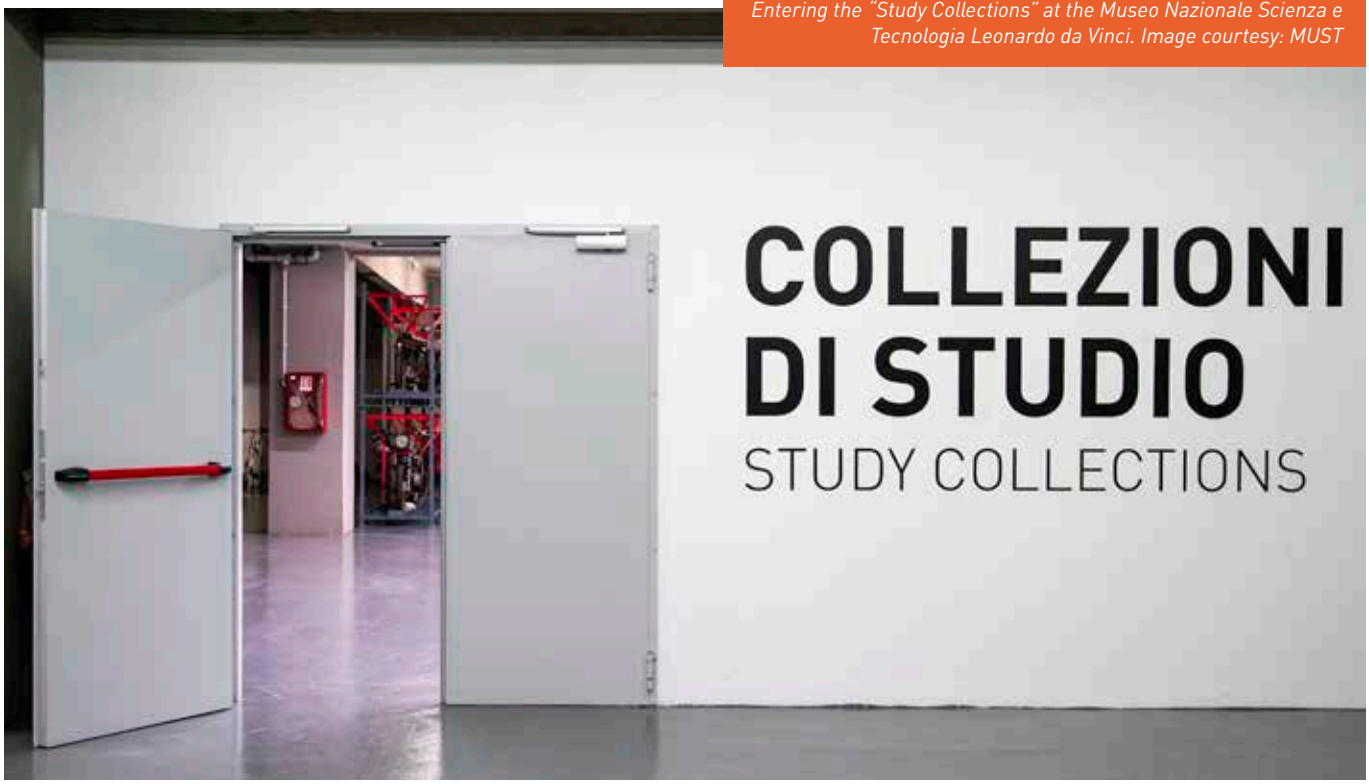


Figure 3
Entering the "Study Collections" at the Museo Nazionale Scienza e Tecnologia Leonardo da Vinci. Image courtesy: MUST

3. THE COMPUTER IN THE STORAGE: DIGGING INTO A SHELF FROM THE MUSEO NAZIONALE SCIENZA E TECNOLOGIA LEONARDO DA VINCI'S COLLECTION

For the second case study, we took into account not a single piece of exhibits but a group of objects in the Museo Nazionale Scienza e Tecnologia Leonardo da Vinci's collection: the "Q shelf," i.e. a physical space in the museum's storage that is identified with the letter Q. The decision to focus on objects in the storage rather than in the exhibition space was due to three considerations. First, it was deemed important to consider how the insertion in different spaces of the museum informed the material, social and discursive dimensions of digital objects. Such a choice could help avoid potential limitations of an object-oriented approach that gives little emphasis to contextual elements that inform how an object is perceived, interpreted, and used (Dean, 2002). Second, recent scholarship has underlined how rigid distinctions between storage and display fail to capture the liveliness of storage spaces. Despite being often hidden from public scrutiny, museums storage is crucial to the functioning of institutions, to the trajectories of objects and collections, and to the experiences of the people who work and research in the museum (Brusius & Singh, 2017). Looking at objects in the storage, therefore, helps consider digital objects in museums under a different and more comprehensive light. Third, the analysis of this case study bore the potential to impact on the Museum's practice, considering that its recent program has included guided visits to parts of the storage, and there was interest in developing a reflection on how objects related to the history of computing in the storage could be presented to visitors of the museum in the future; this was fitting with the practice-based approach of our research.

As a national institution boosting a collection of around 19,000 objects of relevance to the history of science and technology in Italy and the world, the Museo Nazionale Scienza e Tecnologia Leonardo da Vinci (MUST) has several storage locations. Our research focused on the storage located at the museum's premises, just "below" the exhibited collection.[5]

[5] *In fact, the storage is nicknamed "Minus 9 Storeroom" by the museum's staff members, as it is located nine meters below ground level.*

This storage houses mostly small and medium sized objects, including some related to the history of computing. Although the storage has traditionally been accessible only to the museum curators and professionals, it has recently been opened to the public for guided tours in special occasions under the name of "Collezioni di Studio" (Study Collections) – one of which involving a guided tour organized collaboratively by Simona Casonato and Simone Natale under the auspices of the Circuits of Practice project (Museo Nazionale Scienza e Tecnologia Leonardo da Vinci, 2022). Such initiatives are meant to give access to objects that are usually not on public display, as well as to provide insight into the practices and work that animate the museum.

Within this storage space, the Q shelf hosts a number of objects, many of which were donated to the museum by private individuals who are part of the museum's community. The objects are grouped in clusters, with one compartment for instance focusing on objects related to gaming, and another one hosting hardware components, such as plugboards. The organization in clusters and the overall shelves in which the objects are located are not irrelevant. On the contrary, as observed by curator Simona Casonato, "the artefact to curate is always 'double': not only what stands on the Q shelf but to some extent the shelf itself that groups the various objects."[6] This resonates with the point regarding the "community of machine" – i.e. the fact that individual objects acquire sense not in isolation but through their relationship and conversation with the wider exhibition – which was made by Mark Priestley in relationship to TNMoC's exhibitions.

For several of the objects, materials providing information on the objects' use are available, including certificates of purchase and warranty as well as personal items that provide information about the people who owned and used the objects. These materials represent a useful entry point into the objects' social and discursive trajectories before they entered the collection. For example, alongside the Olivetti Quaderno, a 1992 miniature notebook, a video manual is preserved that provide insight into the narratives that were offered to the public at the time. Materials such as questionnaires that give information about donors provide opportunities for interesting discoveries, too: for example, curator Simona Casonato found out that a person who donated a number of IBM plugboards has been a very close collaborator of Jesuit priest Roberto Busa, a key figure for the history of computing in Italy and a pioneer of computer linguistics of international stature (Jones, 2016).

Such details open up opportunities to present the collection of Shelf Q, in guided tours and other initiatives with the public, not as inert traces of the technological past (Sumner, 2016), but as lively objects that hint to the experiences of those who owned, used, and valued them in the past. As Haines and Woodham point out, in fact, objects in museums' storage are never "at rest": "whilst in storage, [they] retain aspects of earlier 'networks' from which they arrived in the collection" and "become associated with new narratives" (2019). The storage, in this sense, no less than the exhibition space, triggers a circuit of meanings that activates the relationship between the material, the social and the discursive dimensions of digital objects. Examining the objects of the Q shelf reminds us that the value accorded to digital objects is never fixed but always in flux, shifting with time, both before and after these objects find their way into a museum collection (Brusius & Singh, 2017).

To make these dimensions relevant and meaningful, the mediation of curators, researchers, and other museum professionals is essential. To understand the material, social and discursive trajectories of digital objects, it is necessary to look behind the curtains of museum practice (Alberti, 2005) – just like, in order to fully understand digital objects outside of the museum, it is essential to consider the experiences of people who interact with digital objects. An important role, in this regard, is played by "geographies of affect," the spatial

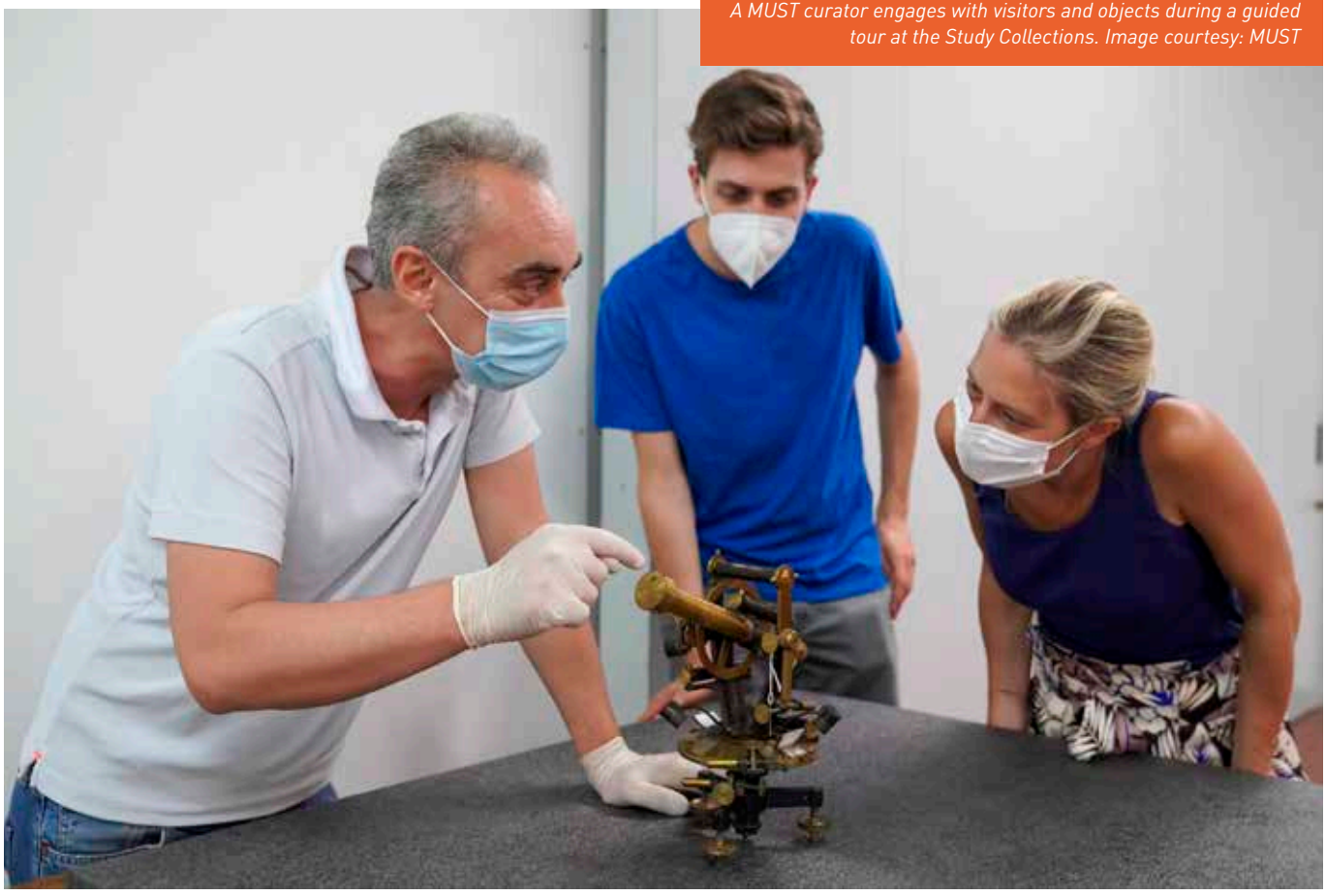
[6] *Personal correspondence, Simona Casonato to Simone Natale.*

structures that inform affective experiences within the museum (Geoghegan & Hess, 2015). In the words of Simona Casonato, the Q shelf was "a part of the collection I particularly care for."[7] Objects in the storage gain affective value as they become the center of a triangle of affect between the curators, the donors and also the visitors, who enjoy the material objects as well as the stories of how they were used and how they reached the museum during visits to the study collections.

The social theory of Erving Goffman provides a fitting interpretative framework to examine the geographies of affect within the museum. In The presentation of self in everyday life (1978), Goffman uses a theatrical metaphor to discuss how people adopt different behaviors and interpretative frames in diverse social environments. In the performance of everyday interactions, he distinguishes between spaces of "front stage," in which people know that others are watching and adjust their behavior accordingly, and spaces of "back stage," where behavior is informed to a lesser degree by the expectations and norms of public spaces. Although Goffman developed his theory to account for social interactions between people, a similar approach helps consider the interaction between people and objects, too: different environments, viewed as "front stage" and "back stage" spaces, shape people's uses of and interaction with objects.

Transposed to the case of the museum, this perspective suggests that the storage can be seen as a "back stage" environment that enables curators, volunteers, researchers and also visitors to construct different forms of relationship to objects, in comparison to

Figure 4
A MUST curator engages with visitors and objects during a guided tour at the Study Collections. Image courtesy: MUST



[7] *Quote from a Circuit of Practice research workshop at the National Museum Science and Technology Leonardo da Vinci, 15 December 2021. For more background on the museum's history and tradition, see Casonato (2019).*

environments that are more "front stage," such as the exhibition space. In the back stage of museum's storage, staff enjoy not only more occasions to manipulate collection items, but also opportunities to construct affective relationship with them. The possibility of privileged access to materials providing information on the objects' past uses can add to this heightened sense of proximity to objects, reminding of Goffman's characterization of back stage as social environments where people construct more easily informal and personal relationships with their peers.

The distinction between front and back stage in the museum (as well as for the everyday experience of social lives to which Goffman originally referred) should not be taken rigidly, since spaces such as the exhibition and the storage are always porous and open to different interpretations and uses. Taking up Goffman's metaphor, however, may help unveil some of the patterns through which meanings circulate and are negotiated among several nodes including curators, visitors, exhibits. The affective links that derive from such dynamics can be fruitfully mobilized through initiatives, such as those organized at the MUST, which bring members of the public into guided visits into the museum storage. As in the case of TNMoC, where the Harwell Dekatron and other digital objects are made "alive" to visitors of the museum with the mediation of volunteers bringing in their experience and affect, the inclusion of the objects in the museum storage does not put these objects "at rest" (Haines & Woodham, 2019): on the contrary, it activates specific patterns through which material, social and discursive dimensions of objects become meaningful to the people who encounter them. The case study of the Q shelf, in this sense, provides further corroboration to the claim that digital objects do not have a "nature" of their own but rather multifaceted, changing dimensions that are activated through specific patterns of interaction, circumstances, spaces and contexts.

4. SOFTWARE IS ALWAYS MORE THAN ONE: CURATING WECHAT AT THE VICTORIA AND ALBERT MUSEUM

For the third case study, we took into account the Victoria and Albert Museum 's acquisition of WeChat, a social media platform with over one billion users, the majority of them in China (Negro, 2017: 193-208). The selection of this case study was due to several considerations. First, in comparison to the first two case studies, the Victoria and Albert Museum (V&A) case allowed us to consider the problem of curating software objects more specifically. Second, the fact that most WeChat users are based in Asia provided an opportunity to take into account how museums consider the global circulation of digital artefacts as objects. Third, the acquisition of WeChat represented for our partner museum, V&A, an important precedent that led the institution and the team who worked on the acquisition to start asking new kinds of questions regarding digital objects and their place in the museum (Cormier, 2017).

WeChat (*Weixin* in Chinese) is a social media platform launched in 2011 by Tencent, a major actor in China's tech industry. Originally marketed as a messaging app, WeChat has taken up more and more functions, such as booking systems for different kinds of public and private services as well as electronic payments (Peng and Wang, 2020). Due to the breadth of available functions and its pervasive role in the everyday experience of many of its users, WeChat has been indicated as one of the most evident examples of the infrastructuralisation of digital platforms. As argued by Plantin and de Seta (2019: 262), "because of the ever-increasing number of WeChat's functions, it has become increasingly hard to live in China without a WeChat account."

The opportunity to add WeChat to V&A's collection was first provided in the context of the exhibition 'Values of Design' for the V&A Gallery at Design Society in Shenzhen. Curators

from V&A met for the first time with members of the Tencent design team in 2015, expressing interest to add WeChat to the museum's permanent collection. As V&A Senior Design Curator Brendan Cormier (2017) notes, V&A curators at this stage "weren't sure ourselves how that might work," due to the particular nature of this object. Curating software, in fact, presents specific challenges to museums, not only for its allegedly immaterial nature but also and especially for its situated and performative character (Foti, 2018). As historian of computing Michael S. Mahoney points out, what makes the history of software hard is that it is not only or even not primarily about computers: software reflects the histories of the communities that created them, and the cultural, social and practical circumstances underpinning its adoptions and uses (Mahoney, 2008). An additional complication, moreover, is that the very functioning of a social media platform such as WeChat relies on the information shared by its community of users. This not only opens up the question of the difficulty to distinguish between software and data, but jeopardise the possibility to draw clear boundaries between digital objects and networks.

As an institution whose mandate revolves around the cultural heritage of arts and design, V&A was strategically placed to tackle such challenges (Atkinson, 2018). In collecting and exhibiting artefacts related to histories of design, V&A throughout its history has often faced the need to consider elements such as the experience of users and the performative dimensions of objects (Burton, 1999). The accumulated expertise and cultural identity of the institution informed the approach of V&A curators and helped them respond to the challenges posed by the acquisition of WeChat (Cormier, 2017).

Approaches that consider reproducibility of technical dimension as crucial to the conservation of digital objects (Link, 2011) tend to consider the preservation of source code, and thus the capacity to reproduce the technical functioning of the object, as essential to preserving software (Di Cosmo, Gruenpeter and Zacchiroli, 2018). Such an approach presents, however, significant problems, including the need to adapt to different standards and programming languages and of preserving adequate hardware and software infrastructures where the software can run. Moreover, the difficulty – often, the impossibility – to have access to proprietary software code makes the preservation of source code impossible in many cases.

The design-oriented approach that characterizes the V&A, in this regard, provided the context to develop a holistic and flexible approach that brought software's social and the discursive dimensions to the center stage. Since acquiring a copy of a social network app would have been of little use without its insertion in the original networked space, the museum acquired not only a copy of the software but also an offline demonstration, in the form of a video, which illuminates crucial aspects of the software's user experience. The acquisition also included materials such as interviews and testimonies of the design process and development of the WeChat interface, as well as a selection of contents such as stickers and GIFs. In V&A exhibition spaces, moreover, WeChat was framed within a wider "community of machines" that illustrated broader trajectories within the history of design. This contextualization in the museum's gallery further emphasized issues such as user experience and interface design for the presentation of WeChat.

The acquisition of WeChat and its exhibition in V&A galleries, therefore, was the result of the recognition that WeChat, like every other software, is not a discrete object that can be described and defined in univocal terms, but a multifaceted object that escapes fixed and rigid attributions of meaning and cannot be strictly separated from the wider technological, social and discursive networks that surround it. As a result, its acquisition within the museum's collection required the assemblage of not one but a plurality of objects that gave access to its multiple dimensions, emphasizing those that were deemed of particular relevance to the museum, its visitors, and its mandate of preserving the cultural heritage of design.

WeChat's acquisition, then, shows how practices for curating software emerge not only and not predominantly by tackling the question of "what is software" in absolute terms, but rather by interrogating what software means from the particular point of view of the institution that operated the acquisition. The framing of WeChat as an object relevant to the history

of design functioned as a prism to project specific dimensions of the object, such as the user experience, which appear central to the contextualization of software within the V&A.

At a discursive level, the exhibition of WeChat activated not to a single narrative but a plurality of narratives. On the one side, exhibiting a social media platform evokes personal experiences of visitors with software and social networks, opening up the opportunity for mobilizing private and collective memories regarding life online (Papacharissi, 2002). On the other side, the fact that this specific platform is strongly characterized as Chinese (Negro, Balbi and Bory, 2020) highlights the fact that digital media are both universal as well as culturally specific (Bell et al., 2018). The acquisition of WeChat, finally, produced a meta-narrative about the agency of V&A itself, demonstrating the museum's capacity to shape new approaches that will impact on the politics of curating and exhibiting digital objects (Cormier, 2017).

V&A's flexible, design-oriented approach to software objects is enabling the institution to further advance its politics of acquisition in the area. The experience with WeChat, in fact, demonstrated that acquisitions of software in the museum's collection can be rigorous and productive even in the absence of elements that other cultural heritage institutions might consider central, such as the acquisition of software's source code. This is important also because it means that the museum might look for future acquisition of other networked, proprietary apps that shape everyday experiences of large masses of people around the world.

More broadly, the case under exam shows that rather than one definition of software, there are multiple definitions that are situated and contextualized alongside specific approaches, contexts, and points of views. While particular dimensions of WeChat were central to its acquisition at V&A, other institutions whose scope relate, for instance, to the history of science and technology rather than design, would have privileged different dimensions of the object and thus might have acquired different materials to be preserved and exhibited at the museum. This third case study, therefore, confirms the overall Circuit's findings, suggesting that software objects, not less than other types of digital objects, are not to be defined in absolute terms but rather against the contextual and the circuitry of relations and attributions that surround and adds "life" to them.

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CONCLUSION

This Circuit report discussed three case studies that helped highlight different stages of curatorial work, different spatial and organizational contexts, and different tasks and professional figures within the museums. Throughout our explorations, it became clear that digital objects within and outside the museum could not be defined or understood in univocal ways. Instead, their definitions, meanings and values emerged through and within a network of relations between the objects, the other objects in the collection, the curators and practitioners, the institutions, and the visitors of the museum.

Importantly, the three cases enabled us to take into account different perspectives through which each institution approaches digital objects and more broadly histories of computing. For TNMoC's Harwell Dekatron, the meaning surfaced as it was impressed upon the exhibit by the volunteers and as an effect of a wider "community of machines." At MUST, the case study showed that the object's values depended not only on the objects themselves but also on their contextualization in different spaces of the museum, wherein the storage emphasized not only the work of curators but also the intertwining between the exhibits' "lives" and the lives and memories of those who used and donated them to the museum. At V&A, new practices on how to curate software developed not only and not predominantly by posing the question of "what is software," but rather by interrogating what software means from the particular point of view of a design history museum.

The practice-based research conducted with our partners provides not just insight into museum practice but also, more broadly, an entry point into the multidimensional nature of digital objects. As Domínguez Rubio (2016) put it, "objects are anything but given or self-evident." The museum functions in this regard as a laboratory in which meanings, uses, and definitions of digital objects are self-reflectively negotiated and where the relational circumstances that characterize digital objects becomes manifest.

Importantly, rather than diverging from the characteristics of digital objects outside of the museum, the trajectories of digital objects in museum's collections and exhibitions prove to be in a relationship of continuity with the material, social and narrative trajectories of digital objects outside the museum (Keramidas, 2015). Much like digital objects become repositories of multiple social uses, meanings, and exchanges as they are created, used, circulated, and eventually discarded in everyday life, so do digital objects establish a relational and iterative social "circuit of meaning" within the museum environment. The relational character of digital objects resonates, furthermore, with the multiple ways in which visitors navigate the exhibitions, engaging with digital objects similar to those they encounter in their everyday life and projecting their own previous experience and ideas about digital media.

Finally, while this Circuit report focused specifically on digital objects, it appeared evident throughout the research that the three dimensions we identified are relevant to non-digital objects as well. As a recent collection also shows, "traditional" objects are inherently mobile and their materiality is never fixed or essentially given, but rather in a state of constant flux (Driver et al., 2021). Rather than conceptualizing digital objects as exceptional and structurally distinct from non-digital objects, in this sense, this collaborative work hopes to stimulate reflections on how the "lives" of digital objects within museum environments helps us to better understand the different, intertwined dimensions of every kind of objects that navigate at a material, social, and narrative level museum spaces and environments.

REPORT OF CIRCUIT 3 "DATA"

NARRATING INFORMATION AND DATA IN MUSEUM ENVIRONMENTS

Circuit lead: Petrina Foti, Loughborough University

INTRODUCTION: THE DATA FORMS IN COMPUTING HISTORY COLLECTIONS

As Felicia Cameron, in her monograph *The Future of Digital Data, Heritage and Curation in a More-than-Human-world*, explains:

> Our very existence has become datafied. Digital Data is omnipresent in what we do and how we experience life: how we record our lives, how we spend our leisure time, how we conduct our work and love lives... Data is embedded in our devices, from the cars we drive to the domestic appliances, the stoves, fridges, and washing machines we use in the seemingly private spaces of our homes. Smart machines embedded with artificial intelligence unleash their capacities onto the world (Cameron 2021, 2-3).

As part of the larger Circuits of Practice investigation in how museums form computer history narratives, Circuit 3 "Data"—comprised of museum practitioners from the Science Museum (London, UK), Bletchley Park (Milton Keynes, UK) and the Computer History Museum (Mountain View, USA)—is investigating how museums can narrate the role of information and data in computing histories. Circuit 3's investigation began with the deceptively simple research question: How can museums narrate the role of information and data in computing histories? The premise is an intriguing one as it gets to the very heart of challenge that software poses for the museum. As Marc Weber, curator at the Computer History Museum, explains:

> Today, we aren't just losing information shared between people. Most of the great machines that have powered our age of instant online communication over the past fifty years are fading like snow in spring rain. We call those machines 'software.' In past ages, machines either survived or were lost. Today many of their physical husks, the hardware, gets preserved. But functionally that's like a watch museum full of empty watch cases with the works gone (Weber, 2016: 57).

To examine how museums narrate data, therefore, is to confront how museums are responding to the digital fragility (Domínguez Rubio & Wharton, 2020) and to the born-digital objects (Cameron, 2007). Data, as it relates to computer history, challenges traditional curatorial approaches to recording history (Foti, 2018) and to the very nature of a museum collection's materiality. Tilly Blyth, Head of Collections and Principal Curator at the Science Museum in London, notes:

> We are in this kind of weird transition, where actually our worlds are becoming less and less "artifact-ual", less and less material, and more and more digital, for wont of a better term. And that poses a set of really, really big challenges for museums, both in terms of how you curate that and also in terms of how you preserve it in the longer term. And then, how do you present it to visitors? What is it to show a program that may have run in the 1980s that actually most visitors will not engage with because it looks fairly basic and fairly uninteresting? So, trying to present the bigger context around computing, rather than just the material object is a real challenge for us (Foti, 2018: 39).[1]

This concern speaks directly to current research priorities not only at the Science Museum, but at the Computer History Museum as well. Yet, as exemplified with the practice of our partners at Bletchley Park, data can and very often does appear as analog. The intangible nature of data positions Circuit 3 as the intermediary between the abstract framing of Circuit 1's ontological investigations into the nature of time and the practical limits of Circuit 2's reflections on the material and social dimensions of museum objects.

THEORETICAL APPROACH: BALANCING THEORY AND PRACTICE

Conal McCarthy, Professor of Museum and Heritage Studies at Victoria University of Wellington, New Zealand, observed that "while there has been much useful academic research on contemporary museums, there is much less coverage of museum practice – especially of the practicalities of museum work – in the museum studies literature" (McCarthy, 2015). Though acknowledging that academic work is usually "written by university scholars who may have little experience working in the sector," McCarthy goes on to note that "one of the key benefits that university research in museum studies can offer museums is critical analysis" (McCarthy, 2015). That is not to say, of course, that critical analysis does not play a large role in curatorial practice. However, the demanding work cycle within an active museum require that deadlines must take priority over other duties and interests. Academic research projects, such as Circuits of Practice, allows museums practitioners to dedicate time and resources for careful scholarly self-critique and institutional exchange.

It is, therefore, perhaps important to pause here to acknowledge the preexisting network of practice within Circuit 3. Professional ties connect the Science Museum and Bletchley Park and have long existed between the curatorial staff at the Science Museum and the Computer History Museum. Furthermore, Research Associate Petrina Foti, who serves as the Circuit 3 lead, conducted part of the fieldwork for her monograph, *Collecting and Exhibiting Computer-based Technology: Expert Curation at the Museums of the Smithsonian Institution* (Foti, 2018) at the Computer History Museum and the Science Museum, which included interviews with many of the current Circuit 3 participants. Therefore, it was a natural extension that the theoretical framework presented *Collecting and Exhibiting Computer-based Technology* informed this current study.

Beyond Foti's work, Circuit 3 benefited from the project's overarching structure of workshops [as discussed below] and "Book Club" sessions. The latter is the affectionate titles for the series of web-based seminars, open to all project participants, conducted as part of the project's literature review. Each week a reading was chosen that was then used to inform larger discussions relevant to ongoing project, such as exhibition and design critique (Keramidas, 2015; Weber, 2016), intangible heritage practices (Kirshenblatt-Gimblett, 2004; Rosner et al, 2018), and concerns relating to object integrity and authenticity (Agar, 1998; Domínguez Rubio, 2016; Yurchak, 2015). This process helped inform the workshop series conducted during the fieldwork stage.

The first of Circuit 3's series of five workshops was dedicated to identifying the prominent dimensions of data related to narrative formation during the collection and display of computing history within museums, specifically:

- What do we mean when we use the term "data"?
- Who are the people and units that collect and exhibit data?
- Why has this been undertaken by the museum (or why has it not)?
- How do these narratives involving data compare and contrast?

The two-hour discussion proved a window in museum practice at the three different institutions. More critically, it emphasized that while data, by definition, is information, how that information is expressed is often subject to the

circumstances in which it being discussed. It was therefore important that Circuit 3 be clear on how "data" might be defined in the museum sector. In response, Circuit 3 then began to construct a framework to better understand and articulate how data is expressed [see Theoretical Framework, below]. The Data Circuit then utilized two of the subsequent workshops (with the Computer History Museum and the Science Museum, respectively) to test the viability of the matrix against past museum projects with the final two workshops in the series (the Science Museum and Bletchley Park) reserved for the practical application of the matrix against current museum projects.

For the institution-dedicated workshops, the Circuit 3 museum partners selected a case study from their current practice that would have a practical impact for their institution. The Science Museum investigated the specific challenges relating to collecting smart technology/internet of things, especially in terms of collecting or representing the data and system networks Bletchley Park examined the display of data relating to their Block A exhibition, currently under development. The Computer History Museum considered their approach to data-driven AI. Fortuitously, these three case studies offered different aspects of the museum practice, namely exhibition development, collection acquisition, and formalizing a curatorial approach to a given topic. Close examination of these three key curatorial functions provided valuable insight into the process of narrative formation within a museum setting.

THEORETICAL FRAMEWORK: THE SYNTHESIS MATRIX

In order to prioritize the practicalities of museum work within our critical analysis, Circuit 3's synthesis matrix' was developed informed in tandem by literature review and questions formulated around data by the partner museums following reflections on their own practice. Utilizing the curatorial methodologies identified in *Collecting and Exhibiting Computer-based Technology*, the "representing method" – when a physical object is used a physical substitute for a complex concept – is the most commonly employed as relates to data [Foti, 2018]. For this study, rather than investigating what would be most appropriate physical substitute, Circuit 3 instead probed what concepts were being represented and for what purpose [See Figure 1]. Ultimately, it was proposed that data (at least as it relates to museum practice) can usefully be understood through the following forms of expression: *bits* as required by discipline; *evidence* in terms of objective analysis; a *lens* due to contextualization; a *museum object* in terms of historical preservation; a *tool* as required by professional practice; and *story subject* due to academic interpretation. Participants in Circuit 3 then utilized subsequent workshops to test the viability of this matrix of data contexts and expressions against past museum projects, with a further cycle of workshops then attempting to practically apply the logic and nomenclature of the matrix to current initiatives within the partner museums. Like a prism revealing the color spectrum, the Data Circuit's Synthesis Matrix has been able to provide a view into the concept of data that invites future study.

Data is INFORMATION	*Due to DEFINITION*	*This is expressed in a variety of way, such as Bits; Evidence; a Lens; an Object; a Tool; a Story Subject.*
Data is seen as ...	*Due to ...*	*Is this expressed in the museum's research interests and outputs? If so, where and how?*
... bits	*Discipline*	
... evidence	*Objective Analysis*	
... a lens	*Contextualization*	
... an object	*Historical Preservation*	
... a tool	*Professional Practice*	
... a story subject	*Interpretation*	

Table 1: The Synthesis Matrix

Figure 5
Exhibiting aspects of the history of computing at the Computer History Museum. Image courtesy: Computer History Museum / © Studio Dizon Photography

WORKSHOPS: COMPUTER HISTORY MUSEUM

It is fitting that the first of Circuit 3's institution-dedicated workshop was featured with the Computer History Museum, given its nearly fifty-year history of collecting, exhibiting and interpreting computer technology for the general public. While the workshop was dedicated to examining the museum's current interest in data-driven Artificial Intelligence, the subsequent conversation was informed by larger issues surrounding digital technology. For example, the museum has an extensive collection of retail-packaged software, allowing the museum to represent specific moments in time in a way that would be accessible and even familiar for many of the museum's visitors. Since downloading is currently the most prevalent form of both software procurement and updating, there is no longer a container to be collected or placed on exhibition. The content – the data itself – must now be faced directly. It is interesting to note that in separate interviews during 2018, all four curators (Dag Spicer, Marc Weber, David Brock, and Hansen Hsu) remarked about the increased difficulty in collecting software in an age of continuous deployment (Foti, 2018, 36-38). David Brock, Director of the Center for Software History at the museum, explains that:

> Without a network and without all sorts of valid credentials, none of the software on these devices will function. So, that really raises a lot of questions, in terms of executable software, about what we do. What can we collect from that? What do you collect when the software is being modified by its maker remotely all the time [through] patches and updates? That kind of issue of versioning is already around in software that used to come to you on some sort of medium, but now, when it is delivered over a network, it is a different problem (Foti, 2018, 36-37).

Hansen Hsu, Curator for the Computer History Museum's Center for Software History, concurs, noting that "there is not a discreet set of milestones. You have to decide when you want to take a snapshot, because it is constantly changing" (Foti, 2018, 37). It is in this environment that the Computer History Museum is now documenting the recent advances in AI technology.

As has been previously established, data can be expressed in many ways, therefore it is not surprising that data plays a number of different roles in AI technology: the software, itself; data sets that inform the technology's deep learning; the personal information that may be revealed, to name just a few. Part of the challenge for the museum is to identify what types of data are of the highest priority to try to preserve. We might therefore conclude that an essential part of forming a curatorial approach to a given subject is defines key terms and concepts in order to better identify what is important to the museum's mission and values.

During the workshop, Marc Weber observed that "the process of creating narratives is happening right now around all this stuff. Some of it if it feels undefined, it's because it is undefined. This is when narratives get formed."3 What significant from Weber's remarks, and indeed the whole workshop, is the awareness that the curators at the Computer History Museum bring to their practice. They demonstrate the knowledge of how their actions and decisions will affect the collecting efforts, exhibitions and public programs in the future in the care that they take to consider their position from the onset. The collective curatorial approach of Spicer, Weber, Brock, and Hsu offers strong evidence that computer history narratives in a museum setting are actively shaped, rather than passively formed.

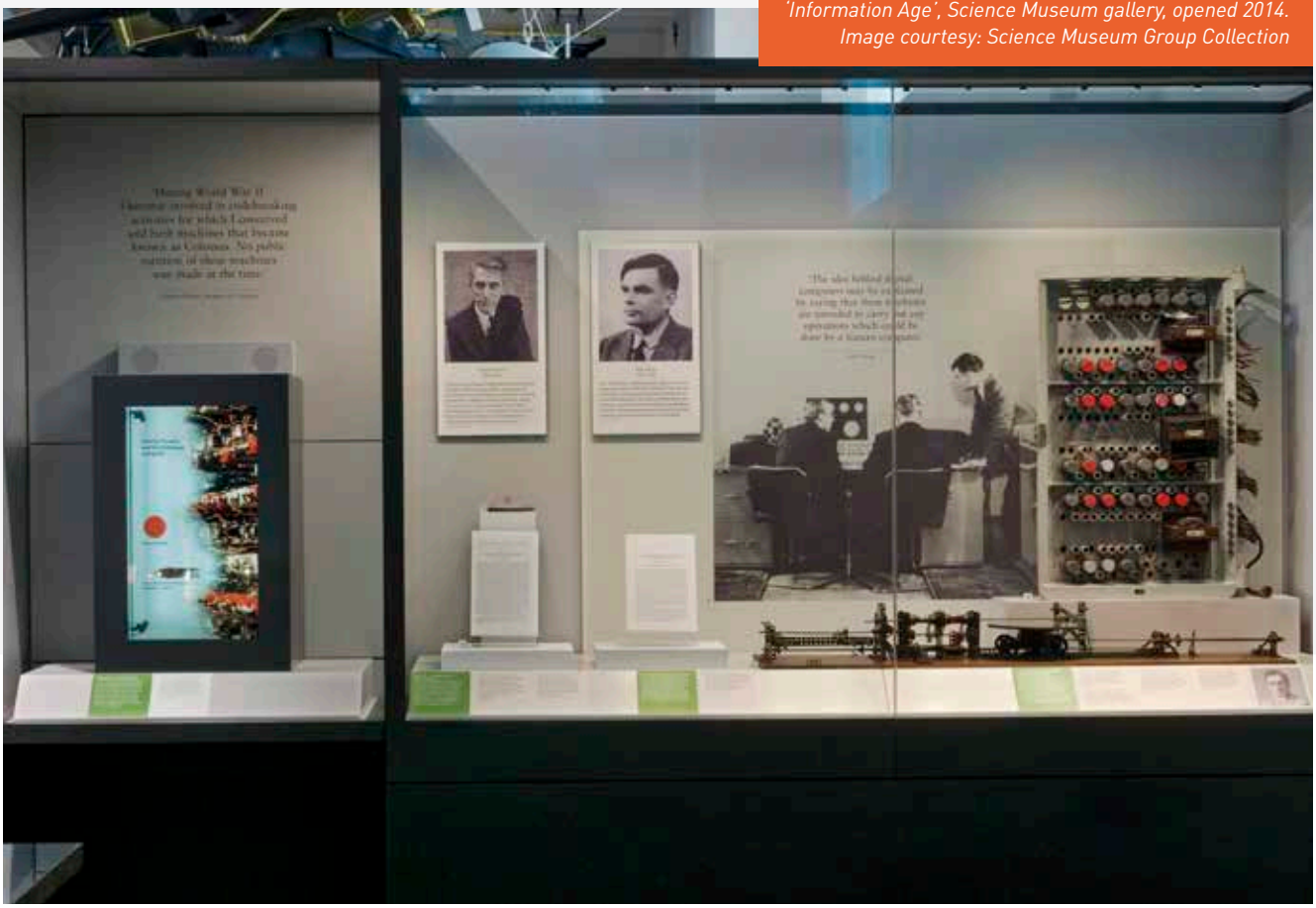

Figure 6
'Information Age', Science Museum gallery, opened 2014. Image courtesy: Science Museum Group Collection

Figure 7
'Our Lives in Data', Science Museum temporary exhibition, 2016. Image courtesy: Science Museum Group Collection

WORKSHOPS: SCIENCE MUSEUM

Once a museum has determined its curatorial approach to a topic, it is in a better position to make informed decisions about its collections and exhibitions. The Science Museum has been concerned with the best way to collect digital material and is actively seek the best method to do so. In a 2017 interview, Blyth explained:

> Museums are brilliant at acquiring and preserving material culture. The artefacts, the objects. We are less brilliant at thinking about digital technology because it is more recent. It is hard to think about actually how you preserve electronics in the longer term. We are very used to paper. We are great at wood. We are brilliant at brass and glass. But, actually, plastics and electronics... the longer term preservation of that type of material is difficult. But also, on top of that, with a computer, you are not just thinking of the physically artifact. Obviously, you are thinking about the software and the program that runs on that machine. And in the age that we are in now, actually, it is less and less about the physical and more and more just that the software itself is a machine! (Foti, 2018, 38).

In Circuit 3's investigation of data allowed the museum to consider one critical aspect of computer technology to bring greater understanding of the whole. To do this, Circuit 3 first examined past practices, before turning to the challenge of collecting smart technology.

The first of the two Science Museum dedicated workshops examined how the Science Museum had previously presented data in their computer and information technology related exhibitions – both permanent and temporary – using the synthesis matrix as a framework. This provided both a practical test for the matrix and a way to reflect on how the Science Museum has approached the concept of data in the past. Fiona Cameron notes that, while there has been much attention given to the digital heritage topics such as digitization and digital communication strategies and literacies, "digital machines and data languish in museum storerooms, and billions of files lie like sediment in the cloud, in hard drives and all manner of devices. Data in itself as a form of heritage has to date received little attention, especially in regard to its theorization" (Cameron 2021, 2-3). Accounting for the different parameters associated with project briefs, all exhibitions examined displayed a complex

understanding of the various forms of data expression, though the museum's increasing digital maturity was reflected in the themes and techniques that the exhibitions presented.

With that understanding in mind, Circuit 3 turned to the museum's current interest in how to collect smart technology in a way that would be meaningful in the future. While smart technology might be represented with an associated piece of hardware, that curatorial technique does not speak to the critical data systems and networks that define smart technology. It was for that reason that the second Science Museum workshop was dedicated to examining collecting digital information and computer code. The curators emphasized that they would like to collect the digital in a way that is meaningful, not simply because they have the ability. In other words, the museum seeks to utilize a conceptional framework to inform their approach, rather than passively let current digital preservation capabilities providing a default position. This, in turn, would require a new curatorial approach, perhaps one informed by interdisciplinary exchange.

With this example from the Science Museum, we can see that when collecting data, the form that data might take is matters greatly. We might therefore conjecture that it is because the form that a museum object takes influences the meaning that can then be extrapolated, both now and in the future. Again, as with the Computer History Museum, we see curators actively seeking to shape the narrative rather than passively letting it form.

WORKSHOPS: BLETCHLEY PARK

Circuit 3's final workshop was with Bletchley Park, unusual among the Circuits of Practice partner both for being a heritage site and due to the fact that, given its primary active years were during World War II, the site limits itself the milestones of computer history that happened during that time, at that location. However, the story of data central to Bletchley park's mission. Though popularly for its role in espionage and decryption, the heritage site emphasizes Bletchley Park's role during the war as a data processing site. To do so, the heritage site utilizes its visitors' digital literacy and familiarity with their own communication networks to draw parallels with how data was used in the wartime effort. Rather than helping form computer history narratives, we see here how a heritage institution uses existing narratives to help illuminate complex concepts. The workshop with Bletchley part focused specifically on the way that data was processed throughout the site, especially as it might be expressed in their permanent exhibition in Block A currently under development in regards.

One interesting aspect that was discussed during the workshop was the absence of data. As common with espionage and counterintelligence, there has been a systematic deleting of the information that flowed through the site. We might even go so far as to propose that Bletchley Park exemplifies a future where no data remains, which is precisely what the Science Museum and Computer Museum are actively seeking to avoid. And yet, Bletchley shows how something as conceptual as data can be presented in a way that is personal and relatable. The traces of the human element remain, from the buildings the codebreakers at Bletchley Park used to inhabit to the marginalia on the documents that still exist. The exhibition's function is to connect the past with the present, so the power of these objects is their ability to do so on a human level.

© Mark Richards Photography / Courtesy of the Computer History Museum [CHM] 1

CONCLUSION: DATA MINDING

The insights gained from the application of the Data Circuit's approach has offered intriguing avenues for further exploration in both academic and professional spheres. As we have seen, each of the three partner museums are investigating ongoing challenges that relate to different aspects of museum practice, taking an active, thoughtful role in shaping their respective institutions' message. The Science Museum is exploring how best to collect smart technology in a way that is able to represent their crucial associated data system networks. Whereas, with a new exhibition currently under development, Bletchley Park is concerned with methods of displaying the data that flowed through the site during World War II, in a way that is accessible and meaningful to a digital age audience. Finally, the Computer History Museum is currently considering the best approach for its curators to take in the presentation of AI-related technology. Yet whether they seek to illuminate the past, contextualize the present, or preserve for the future, all three museums are concerned with larger systems of data and how these might best be represented in a museum setting.

This is further complicated by the possibility that current practice may prove unsuited for such an undertaking. For example, as revealed in the project workshops, while it is possible for a museum to collect and exhibit digital objects, the process of archiving does not necessarily encompass digital technology's associated ecosystem. The reflections and insights of the three museums of Circuit 3 have highlighted and articulated the need to record the infostructure of data, which is a reflection of larger history of technology concerns. Moreover, their responsiveness to this challenge begins to show ways of how the museum sector's digital collections practices might need to evolve faced with continued digital technological progress. This in turn called for a reexamination of curatorial practices with the larger of scope of museology's long tradition of material culture (Knell 2007). Ultimately, Circuit 3 both reaffirms the need for future academic study into the curatorial practices associated with data and digital information and calls for a more thorough examination of curatorial practices across the sector.

CONCLUSIONS AND FUTURE WORK

Since the outset, one of the objectives of Circuits of Practice was to create a community of practice, bringing together curators in leading international museums that engage with the history of computing and university-based researchers interesting in histories of computing and digital media and how they can be exhibited and narrated in museum environments. The key contribution of this project has been the construction of this community. As the project comes to an end, the community continues to be engaged through the "Circuits of Practice Book Club" – a regular online discussion in which participants in the project and other scholars and practitioners share and discuss relevant literature to the project, including their own work. The Book Club has proved to be a valuable way to connect with our project partners and engage with academic literature outside of our individual professional interests, fostering an interdisciplinary community of academic peers. At the moment of writing, the Computer History Museum has provided the digital infrastructure for carrying forth the Book Club after this project's conclusion, and the reading group is livelier than ever under the lead of Petrina Foti. We anticipate that these sessions will continue long after Circuits of Practice has formally ended.

In terms of overall findings, our research provides narratology and narrative studies with a unique context in which to observe how narratives can be constructed through objects in institutional settings – and the complex ways in which organisations, markets, society and the public concurrently shape this narrative. Similarly, our reflections on 'data' and 'society' provide collections management practices inside the museum with the context in which to confront and think through the challenge of not just using but collecting 'information' and 'systems' – and the unorthodox ways in which 'data' appears to decline the usual typologies and nomenclature of 'tangible' and 'intangible' heritage. Likewise, our examination of the confidence and capability with computing in these displayed histories provides further insights to our understanding of the evolving postdigital museum – not least the self-reflexive ways in which the institution's on-going collecting and interpreting of digital technology (through these computing history exhibits) becomes an analogue of its growing digital maturity.

The project's findings, moreover, call for fields such as media studies and computing history to consider more fully the key role that museums play in constructing narratives about the history of digital media. Although the myths and narratives that underpin the so-called "digital age" have recently gained much attention in these areas, the role of museums in this context has been until now scarcely explored. Research presented in this report shows how the relational and reflective nature of museum practice can provide a crucial resource to envision new ways to tell accessible, historically nuanced, and evidence-based narratives about "the digital". This is particularly important in a moment when public debates about the governance of digital technologies drive the future of our societies.

The findings present in this report are not intended to provide any final word of solution, but to start a larger conversation on how museums can continue to make histories of computing and digital media relevant and engaging for large communities of visitors across the globe.[8] This conversation has also been carried out with an initiative promoted by Circuits of Practice from December 2021 to February 2022 under the lead of Kimon Keramidas (New York University) and Ross Parry: the "Digital Atelier," an ensemble developing alternative, challenging, creative ways of understanding and sharing the project's findings. As the project came to its conclusion, the Atelier activated the creative work of three researchers and designers – Elisabetta Gomellino, Molly Shand, Amelia Taylor – who moved from the findings presented in this report to generate responses to the three 'Circuit' themes within the project. The work of Digital Atelier's participants was meant to bring forth a provocation, an extension, or a realization to the theories and insights of the project, each unsettling as much as demonstrating our new understanding of computing history in the museum. It originated from our realization and strong belief that the work of a "community of practice," such as the one that animated Circuits of Practice, cannot be incapsulated into any written report. It needs to raise questions rather than give answers, to be constantly and repeatedly challenged, further developed, and reframed.

At a methodological level, therefore, the project's practice-based approach shows that impact on practice can only be achieved by constantly activating the circulation of information and energy. This is, after all, what electronic circuits do.

> *"The project's findings call for fields such as media studies and computing history to consider more fully the key role that museums play in constructing narratives about the history of digital media."*

[8] *The project's website, www.circuitsofpractice.net, will continue to report on the work that started within this project, including Circuits of Practice's Digital Atelier and the Circuits of Practice Book Club.*

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circuitsofpractice.net

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