Exploring Space(s):
Queer feminist approaches to understanding pedagogy in science museum galleries

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Declaration

I, Eleanor S. Armstrong confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.
Abstract

Queer and feminist approaches to museum practice are increasingly evident across the literature on socio-historical, arts and historic house sites, making innovations in the forms, functions and working procedures of such institutions. Simultaneously, science and technology studies broadly, and Outer Space in particular, are seeing growing pluralisation in methodological approaches including use of queer and feminist techniques. However, there is a dearth of investigation on science and technology museums. My thesis addresses this gap by offering new critical approaches to narratives in galleries focused on Outer Space and demonstrating the innovation and limitations of tour guiding interventions into such institutions.

My queer feminist methodology instrumentalises five questions that guide a critical approach to investigating the pedagogical power of narratives of science and scientists (both broadly constructed) in three science museum galleries focused on Outer Space in London (Science Museum, Natural History Museum, Royal Observatory Greenwich). By being attentive to the knowledges, my thesis answers two research questions that tackle what narratives are present or absent around performed gender and sexuality identities, as well as other attendant concerns that emerge through my queer feminist methodology.

The third research question explores the work that alternative approaches to narratives can do in a museum setting, following the example of a guided tour. Using the case study of ‘Queering the Science Museum’, a tour that I developed and ran in 2018, I explore the benefits and limitations to such interventions.

I conclude by curatorial dreaming – imagining alternatives in the gallery spaces – to reflect on the knowledge brought together through my thesis. By engaging with a queer feminist approach of situating knowledge, my thesis both highlights a gap in research about science museums and Outer Space and provides documentation and theorisation of the evidence.
of existing exhibits. It therefore directs future work that moves towards mechanisms for changing the narrative power in public discourses of science.
Impact

My thesis builds on emerging museum activism threads and queer feminist movements in arts and socio-historical museums, galleries and archives, but adapts and develops the theory in the context of the science and technology museums. Such museums have been broadly theorised from history of science, science education and science communication angles, instead of activism projects. The important early steps my work has taken have been recognised by eminent museum theorists as addressing “a gap in a field that often avoids attention around queer and gendered analysis” (Parry, Dodd, Wajid, Sandell, personal correspondence¹), and through publication and conference dissemination will make further impact on theorisation and practice. The work is also of interest to the space science community, and has the potential to impact practice in the field.

I have been invited to convene and deliver a workshop at the Vienna Technical Museum: Outer Edge: Queer(y)ing Science Museum Collections with Dr Gerber. The one and a half day workshop in March 2020 bringing together professionals from around the world to share practice, projects, and ideas. The host institution has seen impact from my work, including looking to make permanent changes to signage for the bathrooms I introduced for the workshop, and developing “a more inclusive approach to collection work and building networks” (Gerber).

My research also has the potential to make significant impact in non-academic arenas. Thus far, my research has had impact on professional practice in museums, through changes to individual practice and the ways that communities develop and produce their work. Informed by my research, my praxis work on the University of Cambridge Museums’ Beyond Binaries tours has shaped curatorial practice at the Whipple, where the stories for the tour I “uncovered challenge reductive heteronormative accounts of past science. In so doing, they challenge me to work both more thoughtfully and more

¹ All further quotes are from personal correspondence in 2020 unless otherwise indicated.
creatively to expose all-too-easily overlooked LGBTQ+ stories and lessons from past science.” (Nall). Moreover, as the tours for the Cambridge science museums are publicly advertised, an educator shared that the queer heritage tours were “especially significant – in terms of how we [the museums] signal our values” (Evans) to members of the Cambridge public. I have also worked with heritage educators at the Victoria and Albert Museum, to bring elements of the reflexive practice embedded in my thesis to their work. Members of the group have shared the impact this workshop has had on them as educators with one noting “it enabled me to discover the gaps in my knowledge in a safe space. Ellie’s approach enabled me to find avenues for personal and professional growth” (Shoulder), and another that the workshop helped them understand why “content that is meaningful to me and helps me think about where and how I want to progress” (Jerome R).

Already this impact is taking place. For example, based on my research I ran Behind the Glass Cabinet, a podcast series with nine different museum professionals discussing displays of science and technical objects in London museums. As of February 2020, the series has been listened to by over 100 people. Museum professionals involved as co-hosts reported that the impact was multifaceted; benefiting them in intellectual (“interesting”, “thought-provoking”), emotionally (“empowering”, “hopeful”) and in other positive (“hopeful”, “exhilarating”) ways. Further, on understanding impact feedback from international museum professional listeners, they cited that the podcast had changed their professional practice helping one respondent to “apply critical perspectives” (anonymous, London, UK) and shaping another’s work “including whose voices, participations, and experiences 'we' (practitioners and institutions) include / exclude and according to whose ethics and ideologies.” (anonymous, Melbourne, Australia). This demonstrates that my outreach projects are making impact in cultural organisation practice internationally.
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Table of Contents

DECLARATION 2
ABSTRACT 3
IMPACT 5
ACKNOWLEDGEMENTS 7
LIST OF FIGURES 13
LIST OF TABLES 15

CHAPTER 1 INTRODUCTION 17

1.1 MY POSITION 20
1.2 RESEARCHER AND RESEARCH SUBJECT 23
1.3 METHODOLOGICAL FRAMEWORK 26
1.4 GUIDE TO THE THESIS 36
1.4.1 TERMINOLOGY 37
1.5 SUMMARY 40

CHAPTER 2: LITERATURE REVIEW 41

2.1 SPACE SCIENCE IN CONTEXT 41
2.1.1 WHO DOES ‘SPACE SCIENCE’? 43
2.1.2 DOING ‘SPACE SCIENCE’ IN OUTER SPACE? 45
2.1.3 DOING ‘SPACE SCIENCE’ ON EARTH 46
2.1.4 DOING ‘SPACE SCIENCE’ IN POPULAR CULTURE 50
2.2 (STEMM) MUSEUMS 56
2.2.1 STRUCTURAL INEQUALITY IN (STEMM) MUSEUMS 62
2.2.2 ACTIVISM IN THE MUSEUM 66
2.2.2.1 Social justice and museum activism 66
2.2.2.2 Exploring activism and social justice in museums 70
2.2.2.1 Museum-led interventions 71
2.2.2.2 Museum-public projects 74
2.2.2.3 Public-led interventions 76
2.2.2.3 Summary 77
2.3 LEARNING IN PUBLIC SPACES 78
2.3.1 NARRATIVES AND IMAGINARIES IN THE MUSEUM 78
2.3.2 CRITICAL PEDAGOGY 82
2.3.3 SCIENCE COMMUNICATION AND THE MUSEUM; LEARNING IN SCIENCE MUSEUMS 86
2.4 GENDER, SEX, AND SEXUALITY 88
2.5 THESIS RESEARCH QUESTIONS 91
2.6 SUMMARY 99

CHAPTER 3 METHODOLOGIES AND METHODS 100
List of Figures

Figure 1: Make-up Kit (No. A20020252000) from the National Air and Space Museum (Image credit: National Air and Space Museum; Transferred from NASA, Johnson Space Center.) ................................................................................................................................. 18

Figure 2a and 2b: Books on sale at the Whitney Plantation (left, Summer 2019) and cotton angel Christmas tree decorations at the Laura Plantation (right, Summer 2019). (Image credits: E. S. Armstrong)........................................................................................................................................ 73

Figure 3: Mae Jemison (bottom) pictured in the Exploring Space Gallery (Image credit: E. S. Armstrong)........................................................................................................................................ 151

Figure 4: One of the BSL interpreters, shown on screen with Prof. Monica Grady’s introduction (Image credit: E.S. Armstrong). ................................................................................................. 152

Figure 5: Helen Sharman’s suit, displayed in Exploring Space at the Science Museum (July 2019). (Image credit: E. S. Armstrong)............................................................................................................ 166

Figure 6: Lisa Ruffa, as featured in the Exploring Space Gallery at the Science Museum (Summer 2019). (Image credit: E. S. Armstrong)................................................................................................. 169

Figure 7: Miss French in the Astronomy Explores Gallery, Royal Observatory Greenwich, Summer 2019 (Image credit: E. S. Armstrong)........................................................................................................ 172

Figure 8: Number of words spoken by individual experts in the film in Astronomy Questions, Royal Observatory Greenwich, Summer 2019. Green indicates someone who identifies as a woman in public profiles, blue is someone who identifies as a man, and the two yellow bars are the narrators of the videos. Titles are taken from the video (even
though some have subsequently changed), with the exception of Green, whom is unnamed by I recognise by sight. ..............................................................177

Figure 9: An example of the scaled temperature and gravity of planets against Earth in From the Beginning, Natural History Museum, Summer 2019 (Image credit: E. S. Armstrong).................................................................207

Figure 10: Display of Soyuz Capsule in Exploring Space, Science Museum, Summer 2019 (Image credit: E. S. Armstrong)..............................................................................................................216

Figure 11: "Life on Mars" display in Exploring Space, Science Museum, Summer 2019 (Image credit: E. S. Armstrong)..............................................................................................................220

Figure 12: Image of western astronomers in Hawaii, taken from the Astronomy Explores Gallery, Summer 2019 (Image credit: E. S. Armstrong). .................................................................226

Figure 13: Image of “UK Infrared Telescope in Hawaii”. Still from Astronomy Questions, Royal Observatory Greenwich, Summer 2019 (Image credit: E. S. Armstrong). .............226

Figure 14: SaU005 Martian meteorite, displayed in From the Beginning at the Natural History Museum, Summer 2019 (Image credit: E. S. Armstrong).........................................................236

Figure 15: Model of William Congreve in Exploring Space at the Science Museum, Summer 2019 (Image credit: E. S. Armstrong).................................................................248
List of Tables

Table 1: Elliot’s grid to investigate artefacts; rotated and with adapted categories from Fleming, 1974. Table from Elliot (1994). .................................................................118

Table 2: The categories used for collecting data in Fleming, Elliot and my study. See Appendix A for an example of complete data table used in the data collection. .......... 120

Table 3: Framework for collecting data about texts in the museum used this research, developed from guidance in Serrell (2015) and Ravelli (2006)..................................................................................121

Table 4: Framework used for interactives in this research, developed from Dancstep and Sindorf (2016, 2018a, 2018b). ........................................................................................................125

Table 5: Number of people in each gallery of this study...............................................145

Table 6: Images or references to people in the galleries without names. .......................150

Table 7: Number of people in video broken down by gender and academic rank.............161

Table 8: Genders of scientists in Astronomy Questions Videos.........................................176

Table 9: Averages of numbers of words spoken by gender and by honorary title given in the videos. ..............................................................................................................176

Table 10: Descriptions of working practice in the astronomy questions videos. Text, grammar and individuals’ titles are taken from closed captioning of the videos. A ‘/’ indicates a new caption [ROG-WAG-V1-16]. .................................................................179
Chapter 1 Introduction

I went to the Smithsonian National Air and Space Museum in Washington DC in 2014. I was doing a summer internship in space science and my mind was filled with rockets, orbiters, coding, and space science research. At the time, I was not that interested in humans in space. I didn’t think to spend time looking at the people who had been in space in the exhibition. Or perhaps I did, but they so concretely centred a narrative of straight white male American astronauts that I already knew so well, that have not thought them worthy memories to hold on to. However, in the ‘Human Spaceflight’ display at the Udvar-Hazy Center of the Smithsonian National Air and Space Museum is a Make-up Kit (Figure 1; Make-up Kit, 2002), designed for the first women who were to fly on the Shuttle. It was designed to complement a grooming and personal care kit that existing (male) astronauts had been given on previous missions. It has labelled pockets with little containers for six items: lipstick, blush, eye liner, mascara and eye shadow, and eye make-up remover – and no space for anything else that the astronaut might want like foundation, concealer, or eyebrow tools.

Rhea Seddon, one of the first six women trained to be an astronaut by the National Aeronautics and Space Agency (NASA) asserts that she wanted a Make-up Kit providing some “basic items” so that pictures from space would not have her “fade into the background” (astronautrheaseddon.com, 2019, §12). According to curator Valerie Neal, “If a woman wanted a makeup kit and her products tested out as okay [by the engineers], she could have it” (Neal, quoted in Dooling, 2018).

Other reports of this item see it very differently: as a “sexist” example of astronauts having to “‘prove” [their] femininity in a male-dominate space like … space …” (Conger & Ervin, 2018, p.107), highlighting Sally Ride’s recollection of this object instead. Ride’s
recounting centres on the “male engineers”, who “in their infinite wisdom, decided that women astronauts would want makeup – so they designed a makeup kit” (Ride, 2002, quoted by NASA History, 2018). Not knowing what to put in the Make-up kit, engineers asked Ride for her thoughts, a task she perceived as being “about the last thing in the world that I wanted to be spending time in training on” (Ride, 2002; quoted by NASA History Office, 2018). While the vivid yellow kit in the Smithsonian’s collection never flew into space, it was not the last made – there are subsequent examples of kits packed with a larger selection of Clinique make-up (e.g. NASA image featured in Pitts, 2003).

The inclusion of the Make-up Kit is surprising if travel to space is framed as being an extreme, masculine-coded, event: one where individuals must do without amenities that we might ‘expect’ on earth, a lens that permits the construction of the Make-up Kit as
“frivolous, irrational and ridiculous” (Pitts, 2003, p.24) rather than something ‘requested’ by astronauts for video link appearances on conference calls and public appearances, whatever the social pressures leading them to feel they need such things. However, perhaps if like Pitts, I look at these Make-up Kits as part of an exercise in detailing which objects and people are meant to be in space:

Just as the spacesuit asks what body we want to bring [to space], space exploration asks what we are willing to work towards. Our answers reflect our definitions of ourselves and our beliefs on a societal and world scale. (Pitts, 2003, p.24)

Whilst Pitts finds “opportunity for expression” (Pitts, 2003, p.24), to celebrate the creativity of humanity against the mechanisation of space travel, I would like to take this object and think queerly about the types of expression that are made possible and for whom.

Sara Ahmed talks about queering use as being the “improper use of something” (Ahmed, 2018, §3), which she directs us to see, through its absence, as being as revealing about the proper use of the thing, as it is about whom the proper user is. In her example of a boy playing with a toy Hoover, she notes: “[c]orrecting the boy’s use of the toy is about correcting more than behaviour in relation to a toy; it is about correcting how the boy is a boy” (Ahmed, 2018).

In thinking about this Make-up Kit then we could not only learn about Ride rejecting a feminist apologist stance and not wanting make-up, or about astronauts like Seddon valuing the possibility of norms of Earth in space, it could, as a material culture prompt, also help us think queerly about how astronauts are expected to be, and why women who were training for the role might reject or confirm that position. Why would a man having this astronaut Make-up Kit be perceived differently to one without the kit? Why is the identity of ‘astronaut’ so deeply at odds with the identity of ‘Make-up wearer’? If we think critically about the use of make-up, it is not just about ‘correcting’ the use of make-
up in space by a person, but also about a ‘correct’ way of using it and the ‘correct’ person using it – it is, to paraphrase Ahmed, about correcting how the astronaut is an astronaut. It is by taking these thoughts and considerations about objects relating to space science, scoping these ideas through ‘getting lost’ in them, underpinned by a queer feminist approach, that I am better able to understand the “unexpected, the improvised and the surprising” (Halberstam, 2011, p.16) turns and changes of perspective that can come about by utilising a queer feminist approach to thinking critically about gender and sexuality in space science.

1.1 My position

As I write up this research project in 2019-20, as part of a queer feminist methodology, I have been reflecting on my positionality within and in relation to this project. It feels difficult to articulate, like my ‘self’ is somehow indistinct around the edges, difficult for me to write down. There are parts that are easy for me to express: I am a financially privileged white woman, living in London. I have had many educational advantages. My parents were actively involved in my formal and informal learning throughout my childhood, I went to a fee-paying school where students were expected to do well in exams, and was coached to this end. I studied Chemistry at Oxford University, where I specialised in planetary science for my Masters, which in turn enabled me to intern at the Lunar and Planetary Institute. There, I was able to meet leading scientists and astronauts, and to visit the Johnson Space Center and other Houston-based NASA landmarks where former colleagues now work. I am in part motivated by seeing the disparity between my global colleagues and the representation of their field of space science in public settings to tackle the research presented in this thesis. I am dyslexic, which I have had support for since before I can really remember. Extra support classes and the concurrent diagnostic testing were a regular feature of my childhood and teen years, but the constant double guessing and under-certainty about spelling, the legitimacy of words, sentence construction, and expressions still sometimes dogs my work. An emphasis on
mathematical thinking, image-based work, and a partial rejection of words led me to studying science. It has also shaped my interest and methods for this research project.

There are parts of me that I find much harder to tie down in words and write about, probably because I am unresolved in how to think about them even in my moments of thinking alone. I am queer. I am a feminist. What do these statements mean about me? Why are they hard to tie down? Queerly, perhaps they are the result of performing many selves for many people. There is no one version of me, and there is no static, atemporal, understanding of me either. Being queer, to me, is different to being bisexual, lesbian or gay as a sexual identity. Being gendered a woman; perhaps it is also something about not quite being on board with that gendering too. My feminism is rooted in addressing the injustice, marginalisation and misrepresentation of women and non-binary individuals across intersections of ethnicity, class, disability, and other marginalisations systematically perpetrated by our contemporary society.

Much of my research, and praxis work that happened alongside it, involved me being in public spaces. Rather than existing in a room alone with my laptop and notes writing this thesis (out of order – queerly – disruptively), I reflect on the fact that in doing social science research, the methods themselves “enact realities, and can help bring into being what they discover” (Law & Urry, 2005, p.394). By being in the gallery spaces I have enacted a reality for myself and others around me. Thus, my positionality is not only how I read myself, but also as a white educator the double image of how others read me in a public space (Seidl & Hancock, 2011). Perhaps some of the identities I inhabit least securely internally are most externally visible. At the time of writing, I have long-ish pink hair, I wear printed dresses with lots of coloured space-based patterns on them, defying “the strictures of the dominant [heteronormative] sex/gender/sexual identity system” (Ault, 1996, p.322), inscribing (Foucault, 1990) and doing (Butler, 1990) both my gender and sexuality. I think of this as a performative (Butler, 1990) way of making, marking (Kirby, 1997), and being visibly queer (Skeggs, 1999) in public and private spaces. Relevant to the tours that form part of this thesis, I have a ‘received pronunciation’ accent, that
marks out my education and where I grew up, and acts as a marker of class as well as geography, education, and gender. However, being white, able-bodied, and a normative body size and height I am an expected, typical (for 2019) visitor within London museums and therefore draw less attention in the locations where my research took place.

Positionality is not just about who I am, but who I am in relation to my research. My doctoral research started by looking at individuals who collaborate across art and science practices. These were often immensely privileged individuals, with institutional support behind them, and frequently the collaborations demonstrated cultural power imbalances that favoured one collaborator or another. However, alongside the start of my doctorate research and writing at UCL, I was working at the London Science Museum.

Passing through the galleries of the museum repeatedly for nearly two years, busy on my way to exploring, explaining, demonstrating, and (I hope!) enthusing visitors about science, I was increasingly aware of the construction of the spaces I was in; not just the words I was saying and the space I was taking up. Why, when I talked about rockets, did we have a picture of Isaac Newton, but when I talked about Zaha Hadid’s geometric architecture, was it an uphill struggle to get her name included let alone an image of her? Where were the stories of scientists of colour, science from the Global South for me to tell the visitors who came to know what it was to be a scientist and do science? Why was the museum I worked at still interviewing and promoting sexist, homophobic, and racist scientists like James Watson? Had I found the ‘wall’ (Ahmed, 2019)? In trying to diversify the material that we worked with, had I become the “wench in the works” (Franklin, 2015) trying to stop business as usual from taking place?

Presenting science in the abstract, away from socio-historic, person-centric narratives, was not unfamiliar to me. As a chemist, my undergraduate degree was filled with ahistorical presentations of science. We didn’t dwell in lectures or tutorials on exactly how science moved from one theoretical or practical position to another – from, for example, developing pathways for making molecules haphazardly to a structured system
of working backwards from the product to starting materials commonly available in a chemical process called retrosynthesis. The ‘Great Men of Science’ were not covered much beyond the laws and processes they gave their names to; but my course was peppered with them: Maxwell’s Equations, Pauli’s Exclusion Principle, Haber’s Process for making ammonia, Schrödinger’s Equation, Hubble’s Law, Bragg’s Scattering Angle, Newton’s Laws of Motion. In my second year I took a course on ‘History and Philosophy of Science’. Looking back through this course for some teaching it is the same eight white, upper class men of Enlightenment and Victorian science that acted as the backbone of that course, who were the eponymous law makers, and were also the same men who populated the science museum galleries I now worked in and resisted in informal science education. Eventually, I quit this job, but only after I had reshaped my research into this thesis, a critical approach to the galleries like those I once worked in.

1.2 Researcher and research subject

The relationship of me as a researcher to my research material can be theorised in various ways. When considered along a problematised ‘insider’ / ‘outsider’ binary (Collins, 1998; Humphrey, 2007; Merton, 1972), the relationship to the research is either that you are closely linked to the subject material – i.e. an ‘insider’ – or that you are not linked to that group, and are therefore an ‘outsider’. After laying out my positionality in the above section, I believe that I could argue that I am both an insider and an outsider to the research subject of science museum galleries.

I consider myself an insider based on having worked at one of the museums in this research, being familiar and well acquainted with some of the galleries that are the focal points of this research, and also being the leader and instigator of the tours that form the penultimate chapter of this thesis. Thus, I benefit from knowing the gallery well, being emotionally invested in the tours, and coming from a position of being queer and a feminist; I have insider knowledge that could bring additional benefit to my research. Of course, it could also be argued that this insider position would lead me to not have what
might be considered the necessary emotional distance for my research. On the other hand, I could consider myself an outsider. I have not curated any of the galleries that are the topic of this research, meaning I sit outside of that which my research brings to light. Of course, this might be constructed as me being too far removed from the process and tacit knowledge of curating, meaning that my ‘objectivity’ and emotional distance may render me incapable of understanding the nuances, or intricacies of the materials I study. This exploration of positions demonstrates a difficult of binary categorisation that my use of a queer feminist approach seeks to challenge – I fit neither the insider nor outsider category well, and arguably, as a researcher, I am in a superposition of being both inside and outside to the research at any given time.

Thus, I reject this binary of the insider/outsider to the research being done, and instead will draw on ideas about research nearness (Mannay, 2012). As Skeggs argues “perspective is always premised upon access to knowledge” (Skeggs, 2004, p.6); therefore, the multiplicities of perspectives that I bring to bear on the research I am doing are a result of many different facets of myself. In some ways I am similar, or ‘near’, to the material I am researching; in other ways I am dissimilar, or ‘far’ from them. By considering these impermanent, changing relations between myself and my research subject, I can understand how I as a researcher am acquainted with the spaces to better inform how these impact on what I can see and what I value as important (Stahl, 2016).

The familiarity with the research subjects that is posed as a problem in the construct of insider/outsider identities does not escape challenge in this model of nearness to the research, as the closeness of the researcher to the research should be always a point of consideration (Delamont & Atkinson, 1995; Geer, 1964). But within this frame of nearness to the research subject, I can instead consider the elastic nature of myself as a researcher – being both near and far to the research subject in different ways, including but not limited to my locality, gender, class, racialisation, institution, history of familiarity (Sthal, 2016).
Finally, thinking through the frame of research-nearness has led me to think about the value and role of the thoughts I have outside of the moments of recording the data in the field. I described above in considering the positionality of my research the importance of passing through the museum when I worked at the Science Museum; but these times were not ‘during’ the research events I have included in this thesis. Mannay and Morgan (2015) theorise these experiences as being important moments of the ‘waiting field’ – where the researcher occupies ‘spaces previous to’, ‘spaces of interruption/disruption’, ‘spaces of reflection’ (Mannay & Morgan, 2015, p.172) relative to the study they are conducting. While, for example, eating my packed lunch outside on the Royal Observatory Greenwich Gagarin Terrace and I heard discussions around me by students or other visitors about the exhibitions; which I can consider in relation to my understanding of the same gallery. This example shows an ethnographic reflection upon moments occupying spaces of interruption/disruption in the waiting field, amongst many others that blur the boundaries to these ‘waiting field’ spaces. Thus, my passing through the galleries daily at work before I began my research I can theorise now as ‘spaces previous to’ my research, where ideas might be captured informally; but later, that same motion through the space to a meeting, to visit a friend who still worked at the museum, or in the company of small children after I had formally collected my data might instead constitute ‘spaces of reflection’ for me as a researcher in relation to my research field.

Moreover, Mannay and Morgan (2015) conceive of the ‘waiting field’ as being both temporal and geographical, citing instances of being outside the house where an interview was to be conducted as ‘spaces previous to’, as well as ‘spaces of interruption/disruption’ being in the location of the interview but being interrupted by other members of a family. Whilst in the previous paragraph I have mentioned the way that a temporal ‘waiting field’ is created in the museum, there are also important geographical ‘waiting fields’ that are created in the visiting of the museum galleries I am researching by me as a researcher. What are the experiences of the ‘waiting field’, and how do the experiences of the ‘waiting field’ around the galleries I have studied shape me as a researcher and my engagement with the content of the galleries? I consider aspects of the museum such as
security check, ticket purchases or voluntary donations (Dawson, 2019), the shop (Larkin, 2016; Procter, 2020), the café/restaurant, the toilets (Mulvey, 2019), accessibility information, as geographical spaces of the ‘waiting field’ that inflect my work as the researcher in relation to my research subject. I posit that introducing concepts such as the ‘waiting field’ is to take a queer feminist approach to the research subject – introducing the possibility and importance of the liminal spaces and times around me as a researcher around the research galleries that I will be looking at. I will return to these ideas as a thread through the thesis, where autoethnographic reflections and vignettes will help illustrate these ideas where I had not planned any additional formal methods to collect data.

1.3 Methodological framework

Neither queer nor feminist are theories in the singular (Sullivan, 2003) but both provide plural perspectives from which to proceed methodologically. Furthermore, the intersections of the two are multiple and equip researchers with different tools, depending on the position of departure. In order to resist a teleological approach to feminist or queer genealogies, I will not be recounting a history of either field. In recounting genealogies, particularly around feminism and queer theory, there is the possibility of both flattening the plurality of movements within the field at any one time and (un)intentionally constructing an inevitable progress and, thus, improvement in thought and action (Hemmings, 2005). I will instead explore how I will use both feminist and queer approaches to challenge the “must” (Parkinson et al., 2013, p.34) of heterosexuality, masculinity, maleness in the construction of science museums in this thesis.

Feminist thought in science studies is:

often cast as inimical to science; in such stereotypic contrasts, science often is taken to be isomorphic with positivist, reductive, quantitative, and value free or apolitical conception of science. (Morawski, 2001, p.58)
Posing feminism and science as antithetical obscures that science (and the representation thereof) is not objective, but instead is regulated by political ideologies in much the way that any other system of knowledge is. Whilst feminist thought provides tools for grappling with assumptions about the nature of science, queer can be used to operate as a disruption to the normative positioning of the questions. Cipolla et al. (2017) find use in conceptualising the value of queer feminist approaches in thinking critically about science as opening a:

figurative space where the meanings of and relations among queer and feminist theories and science are reimagined capaciously to foster new critical and creative knowledge-projects. (Cipolla et al., 2017, p.4)

Understanding the museum as a knowledge project ‘outside’ of a normal ‘science’ institutions, but one where many people interact with science in a way that informs their understanding of both science and objectivity, the use of queer feminist approaches will be to challenge the singular, overwhelmingly mono-disciplinary approach that has been used to date. Rather than recounting the two separately, I shall knit together the concerns of queer theory and feminist theory to demonstrate the articulation of a queer feminist methodology for my thesis, situated in science studies and museums. This will be framed by the following six questions about ‘science’ and how it is represented in a science museum.

First, who is producing what kinds of scientific knowledge? Feminist theorists have thought expansively about how science is produced (including, for example Harding, 1991; Keller, 1983; Longino, 1990), while queer scholars have paid particular attention to the production and naturalisation of binary notions of sexed anatomy, gender identity, sexuality and desire (Downing et al., 2015; Fausto-Sterling, 2000; Gupta, 2015; Halberstam, 2005; Patton & Sánchez-Eppler, 2000; Willey, 2016a). Moreover, there has
been extensive discussion about who gets to decide what is constituted as science, and by extension science studies (Roy & Subramiam, 2016; Willey, 2016b).

Reflected into the role of science museums, we may consider this in multiple ways, including, most importantly: what counts as science, and therefore could be included in a science museum, and which ideas about science are stabilised as scientific knowledge in the museum. For example, as Das and Lowe (2018) document, the science museum as we see it today is built from an Enlightenment desire to categorise the world, breaking it down into neat, disciplined boxes. This systematisation takes a dual approach of asserting the objectivity of the museum specifically and science more generally, and of hiding any indication of who did the preparation, collecting, research, knowledge construction (especially if these identities don’t match with who is expected to have done that work within a normative scientific narrative discourse). Indigenous peoples, along with other minoritised groups, and their knowledge that guided, catered, and worked alongside European ‘collectors’ and ‘explorers’ are written out of presentations in museums – along with scientific uncertainty, boundary cases or outliers, and any political motivations about ascribing categories with particular roles to the world. Impey and MacGregor (1985) document the role of early collections belonging to wealthy gentlemen with means bringing back ‘wonders’ and demonstrating privilege, especially when they were old, or erotic objects – collections which went on to be the foundations of most major western museums (Schiele, 2008). Subsequently, these same collections and their additions were used to demonstrated that galleries played key roles in inscribing “nationality, masculinity, colonialism” (Duncan, 1995, p.21), as well as being a place to ‘wash’ new money (Handler & Gable, 1997). Applying a queer feminist critique to science unveils the way that these ideas and ideals are reinscribed and stabilised in the museum (Jasanoff & Kim, 2015), and opens a crack in the certainty, the objectivity, of representation in a science museum space.

Secondly, it is also possible that utilising a queer feminist approach to understanding science and science museums enables posing questions about how science reflects the
social assumptions of the time, and how these science museums justify, create, and enforce inequalities (Fausto-Sterling, 2000; Haraway, 1992; Keller, 1992; Schiebinger, 1993). Scholars have been attentive to the construction of gender-normative, racist, heterosexist, classist, ableist categories; and how those at the intersections of such categories are further marginalised (Brah & Phoenix, 2004; Crenshaw, 1991; Collins & Bilge, 2016; Spiller, 1991), including thinking critically about racializing queerness and queering race (Somerville, 2000). Challenging the essentialist nature of these created, ‘neat’, socially-informed categories, including most fundamentally the category of a ‘woman’ (Held, 1993; hooks, 1981; Kristeva, 1981; Scott, 1988; Truth, 1851) is the cornerstone to my feminist understanding of the ways that categories are used to justify and enforce inequalities. Queer scholars have also addressed how the social construction of sexuality (Stein, 1990) and the modes of heterosexist regimes intersect, reinforce, and reproduce structures of racialisation, class, gender, nation, age, and ability in uneven ways (Arondekar, 2009; Boellstorff, 2005; Ferguson, 2004; Grewal & Kaplan, 2001; Holland, 2012; Stallings, 2015), highlighting that “sexuality never exists as a discrete category, but is always inflected by class, gender, race, religion, … nationality” and ability (Pearson et al., 2008, p.2). Queer and feminist science studies tackling these questions include Koedt’s work on vaginal orgasm and the consequent construction of deviant female sexuality (Koedt, 1970); the roles of the egg and the sperm in biological text books (Martin, 1991); the construction of gender and sexual diversity in animals (Machin, 2006); the pathologisation of homosexuality and gender non-conformity in the HIV/AIDS epidemic (Crimp, 2002; Epstein, 1996; Treichler, 1999); the medicalised treatments of intersex individuals at birth (Kessler, 1998) or later in their life, for example in sports competitions (Parks Pieper, 2016).

However, social norms co-construct not only the science being done but the way it is displayed in science museums too. Haraway’s work on the American Museum of Natural History’s specimens provide a case study in understanding the use of natural history collections to cement the socially constructed gendered, racialised, and western-centric
norms within the museum (Haraway, 1984). Machin subsequently documented displays in natural history displays in Manchester where:

Male specimens dominated female specimens with respect to number, the postures and positions in which they were displayed, and in the quantity and style of language used in interpretative text. (Machin, 2008, p.54)

Looking at a large-scale cross-collections analysis in six large museums in Europe and the USA, Cooper et al. (2019) found a similar domination of male specimens, with particularly prevalent gendered bias in favour of male specimens in name-bearing species and in those having an obvious sexual dimorphism in males. Scholars have also theorised about the way gendered or sexualised individuals are represented in museums (Levin, 2010, Adair et al., 2020), including characterising the roles of women as relatively passive, shallow, undeveloped, muted, and closed, whereas the roles of men are, in contrast, relatively active, deep, highly developed, fully pronounced, and open (Porter, 1985). Research elsewhere has detailed this imbalance in relation to the seniority and types of roles women occupy in the museum (Schwarzer, 2010), as well as documenting the long history of activist interventions such as those by Guerilla Girls (2015), Andrea Fraser (2005), and Anne Hunt (www.npg.org.uk, nd).

Queer approaches also inform critiques of non-human, non-animal subjects (Giffney & Hird, 2008). Reading these in conjunction with Ahmed’s queer use (explored earlier), van Oost’s theorising of the genderscript of an object allows me to grapple with the premise that a technical object belays an intended gender as either an “explicit or implicit element in the design process” (van Oost, 2003, p.193). Much like gender, genderscripts of objects are constantly negotiated and what may appear as feminine in one context can be read differently elsewhere or elsewhen. In museums this might inform the types of technical tools on display (Keyes, 2019), how they are displayed (Oudshoorn et al., 2002), the colours associated with the tools that are produced (Who Owns Pink?, 2019), and the objects that are selected to demonstrate a point. For instance, Summers articulates how
women in the Victorian Age are thought of in the UK in an idealised, clean, and pristine way by visitors to museums because the stained or patched clothing items held by collections were not on display (Summers, 2000). Along with the choices around displaying identities and the implicit binarised genders dominant in collections, these gender scripts feed into constructions of femininity and masculinity. Elsewhere in educational literature, including in science classrooms, scholars detail how this leads to constructions of the feminine as emotional, frail, cooperative, dependent (Francis, 2000), passive and non-scientific (Dam et al. 2014), whereas the masculine is constructed as rational, strong, competitive, independent (Francis, 2000), active, and scientific (Dam et al., 2014). Further to constructing binaries of gendered roles, Butler argues that constructions of gender and sexuality are never fully differentiated – the construction of distinct genders is needed for the construction of heterosexuality, (re)creating the categories concurrently (Butler, 2004). Considering queer as a disruptive influence against co-construction of binarized identities through science and technology, I will challenge the dichotomous and oppositional constructions of femininity and masculinity as mutually exclusive; I return to this challenge particularly in relation to some frameworks detailed in my methods section that I utilise in my research.

Having thought about what science is, who does it, who decides what science is, and how it is co-constructed with social norms; queer feminist approaches can also be used to think about reforming epistemologies, methods, and interpretations of science (Roy, 2008; Subramaniam, 2014). Queer theory introduces the questioning of logics of systems, discourses, and practices (Ahmed, 2019; Berlant & Edelman, 2013; Butler, 2004; Duggan, 2003; Edelman, 2004; Eng, 2010; Patton, 1990; Puar, 2007; Wilson, 2015), and instrumentalises the construction of normalcy and deviance (Foucault, 1982) to reshape those in the social world’s ways of knowing and mechanisms used to know about themselves (Barad, 2007; Wilson, 2004).

Museums as systems of knowledge formalise particular ideas about what appropriate objects of knowledge are in the collection, and what could ‘properly’ exist in the
collection. Queer challenges to oppositional readings of what should be either ‘in’ or ‘out’ of the collection could lead to productive methods of thinking about loans, co-collection or co-curation, and alternative roles within the museum. In attempts to include those who might historically have been constructed as ‘Other’, or ‘outside’ within the museum, the museum becomes more explicitly political in moving to be a place where knowledge is made rather than a ‘temple’ of passive receipt of knowledge (Hein, 2010). Many museums that do queer or LGBTQ+ focused exhibitions or tours can still end up reconstructing ideas of normalcy and deviance within the queer community – celebrating ‘normal’, young, white, male, able, and hyper-sexualised queer individuals, at the risk of constructing a ‘deviant’ queer as oppositional to this. When Mills (2010) discusses introducing queer into a museum as situating the building knowledge in relation to artists, subjects or community relevance, it is imperative that critical queerness is used to think about which modes of queer knowledge, which objects of queer knowledge and which communities are being constructed through inclusion in performance (Butler, 1993) and discourse (Foucault, 1981), and thus which are still being considered deviant. Cipolla et al. (2017) suggest that we could also frame this as an ethic of ‘undoing’ – how do our epistemologies, in relation to science (and museums), shape their ontology? I intend in this thesis to introduce to both science studies and the museum field the ideas of uncertainty, transformation, play; of queering the use of ideas, objects, displays (Ahmed, 2018).

These challenges to the epistemology of science and the museum can in turn be applied to reformulate conceptions of the social world (Barad, 2007; Wilson, 2004). Always attentive to the politics of power, politics of difference, politics of privilege we are able to understand queer as not a fixed or essential identity (Butler, 1993; Cohen, 1997; Edelman, 2004; Foucault, 1981; Spivak, 1988) but transient, transgressive, and relational (Davidson & Rooney, 2018). Indeed, to make strange (or queer) that which seems normal or natural (Sedgwick & Frank, 2003) is a fundamental way of developing knowledge about individuals, such that:
any aspect of Western culture must be, not merely incomplete, but damaged in its central substance to the degree that it does not incorporate a critical analysis of modern homo/heterosexual definition. (Sedgwick, 1990, p.1)

Queer feminist framework has the possibility of challenging entrenched divides between disciplines, and foregrounding new approaches to critical interdisciplinarity (Subramaniam, 2014). Consequently, to appreciate that both the social world and the theorisation of it are iterative and changing, we must recognise that “the story we tell of these developments must be provisional – this in itself is a queer feminist recognition” (Jones & Silver, 2015, p.5).

In this lens of using the object of my study – here science in museums – to shift the conceptions of the social world, we can see the importance of feminist, queer, and queer feminist shifts within exhibition development. For instance, Ferentinos highlights the display of the changing nature of social norms, where:

[v]arious eras and cultures have defined the boundaries of what is considered “normal” differently, and by exploring those differences – and the experiences of those who were considered “abnormal” – we can catch a glimpse of the assumptions and priorities of the larger group. (Ferentinos, 2015, p.7)

By embracing the provisional nature of stories about historical identities, there is not only a challenge to the expected position of the museum or curatorial authority, but additionally provision for:

the small cracks and fissures in the heteronormative foundation of the museum — spaces through which the roots of new curatorial and educational performances may take hold. (Sanders, 2016, p.24)
Thus, queer feminist approaches most importantly recognise the mutually constructing process between being and knowing (Barad, 2007): that the two are never fully differentiated and therefore should not be considered separately. Challenges to ways of being in a space shape the knowledge of that thing, and iteratively so. This chimes with Halberstam’s construction of queer time – non-linearity in resisting the idea of time as sequential, or that instances must occur one after another. Instead, it is possible to conceive as multiple things happening at once or happening in a recursive loop, being impossible to differentiate or separate (Halberstam, 2005).

In summary, there are five (intersecting) axes along which my queer feminist approach has been articulated, and will attend to. This methodology will help me look at what science is, how science is constructed by social culture, the methods of changing and challenging epistemologies and therefore how these reflections could then also reshape society itself. Importantly, my methodology recognises that in a queer feminist approach these constructions are never fully differentiated to how the constructs inform my approach. While normative traits may be embedded and resisted at the individual (visitor, curator, scholar) level, they are also transformed and reproduced at the societal (public, museum, academia) level, allowing my study of the representation of science museums to operate on multiple strata. The importance of declaring museums as sites of politicised knowledge construction cannot be overstated. Indeed, born out of a social justice movement, the popular #MuseumsAreNotNeutral campaign pulled this understanding of the museum to the forefront of a wide range of people’s attentions (Autry & Murawski, 2017).

Such foci permit developing “[c]ritical and creative interventions” (Cipolla et al., 2017, p.5) into the museum spaces I study. My queer feminism is not just ‘about’ or ‘for’ those who are queer feminists, but is rather a way of engaging with and understanding the world. Additionally, while I have centred the queer and feminist roots of my queer feminist methodology here, I note that my methodology is additionally informed and underpinned by ideas of disability studies, ecofeminism, museum studies, science
education studies, postcolonial science studies, reproductive justice movements, queer of colour critique, transhumanism, sci-art and science fiction of all forms, media studies, cultural studies, and science studies. I will not spend further developing these intersections at this point, but will draw on these literatures through my thesis. So, whilst my thesis takes a queer feminist methodology position, the work itself is grounded in critical theory (for example, Friere, 1968; Giroux, 2011). In museums in particular, the exclusion of counterhegemonic narratives of racialisation, gender, sexuality, class, ability, geographical location, and culture are tied together; whilst this thesis is especially attentive to gender and sexuality, these should not be read in isolation, but inseparably intertwined through their intersections.

My methodology enriches the field of science museum studies, and bridges queer (and) feminist museum studies with queer (and) feminist science studies. In my methods chapter I will articulate how I will take a queer feminist critical education approach to spaces that are simultaneously constructing norms of science and norms of museums. Through attending to the norms of expected relationships between gender and sexuality, and science, I shall further illuminate constructs in both fields. My thesis, then, is built on a queer assemblage of wanting more for science and educational studies, for informal science education in general – and in science museums specifically. Wanting to understand what is in galleries against what could be there is not just an exercise in selecting individuals and their stories to include. For me, it has been understanding that the construction of the museum is always a simultaneously relational construction of dichotomies: of whiteness-Blackness; man-woman; male-female; heterosexuality-homosexuality; science-non-science. These are not fixed, firm, oppositional binary boundaries, but are read one relationally to each other. And, in foregrounding my queer feminism as methodology, my thesis can be read as a long-form discussion of my thoughts and my work at this time and rejection of these binaries. Recasting queer feminism as relational and ongoingly transformative, I strongly believe my thoughts and work will change and develop going forwards from this point as I continue thinking, working, developing materials.
1.4 Guide to the thesis

This thesis will proceed with a literature review, and will then introduce the methods I have used and how I have adapted them for the research that constitutes this thesis. Through the context of existing literature, I will build towards the research questions:

1. What gender and sexuality narratives exist within London space science galleries?
2. By being attentive to the presence of the curated gallery space, what is absent in the gallery?
3. Through understanding these inclusions and exclusions as exercises of power, what are of ‘alternative’ approaches to power, identity, and futurity in the museum gallery?

I will then demonstrate how the adapted methods I have selected have discursive potential for interrogating these questions. The subsequent chapters are broadly guided by the questions I have articulated in discussing the queer feminist methodology above. In Chapter 4 I will present my reflections on constructions of genders and scientific identities in relation to gallery displays of scientists, and in Chapter 5 I will critically articulate the influence of epistemic knowledge-making acts in relation to universalising scientific knowledge and marginalisation of locations on Earth. In Chapter 6 I will consider the co-construction of knowledge by the visitor and the exhibition through the discussion of the ‘Queering the Science Museum’ tours; finally, in my conclusions I shall reflect on the ways that a queer feminist approach to science museums has demonstrated alternative views of displays, and will think though some future directions that can challenge and change hegemonic narratives.

Throughout the thesis, and in the rest of the work I do, I am guided by the encouragement that citation is a political act (Ahmed, 2013), as is capitalisation (Tharps, 2014). Thus, this
work contains citations of works outside what might be considered ‘the academy’ and draws widely therein. Indeed, even in choosing a font for the publication of this thesis I was inspired by this maxim, and have chosen Lusitana by Brazilian typographer Ana Paula Megda (Megda, 2020).

1.4.1 Terminology

Drawing on Redfield (2000), and Curran (2019a), I include below a brief glossary. These are terms that I will use repeatedly in my thesis; I want to give a working definition to aid clarity.

**Sex/Gender:** Queer feminist approach to thinking about sex/gender as being a reconfiguration of biology/culture (Fausto-Sterling, 2012; Fine, 2010; Jordan-Young, 2010) – neither opposed nor simply mutually constitutive, but entangled with other categories. Seeing them this way allows intersex/trans to not be subjects of exceptional study, but rather sites of their own issues (e.g. Trans Theory), and central to larger debates.

**Queer:** Used as a verb to describe an action (to ‘queer’ the museum), or as a noun to describe a sexual identity. Queer theory focuses expansively on gender and sexuality as social constructions – in contradictions to sexual ‘norms’ of western heteronormativity. Queer has historically been used as a slur against members of the LGBTQ+ community and thus is sometimes rejected by some members of the community.

**LGBTQ+:** Lesbian, Gay, Bisexual, Trans*, Queer, + (usually used to signify allied identities, such as intersex, asexual, aromantic). LGBTQ studies can be thought to be focused/focuses more specifically on particular populations and their marginalisations within society in comparison to Queer studies.
**Intersectionality:** Co-constitution of sexing/gendering bodies with racialisation, class, disability, geopolitics – i.e. the categories are not stable, neat; but importantly diverse and multiple unto themselves (Bhopal & Preston, 2012; Collins & Bilge, 2016).

**Cis/cisgender:** Individuals whose gender identity is aligned with the one they were assigned at birth. This is an identity that is naturalised by science and culture as normative, but much as discussing whiteness and maleness destabilises these as natural categories, foregrounding cis identities helps draw attention to them to challenge their normalcy.

**Trans/trans*/transgender:** Often used to encompasses a wide range of identities of individuals whose gender does not match their sex assigned at birth, including binary trans people (i.e. those assigned male at birth who identify as female and vice versa). It can also be used to refer to non-binary/gender-queer/gender non-conforming individuals too (i.e. those who identify outside of and beyond the male/female binary).

**Pronouns (They/He/She):** Terms used to refer to individuals in the third person. In this thesis I will use pronouns that individuals have asserted at the date of writing where known, but will also be using ‘they’ for any individual whose gender identity I am unsure of. It should be noted that using ‘they’ in the singular is also used as a choice and expression of a non-binarised identity, and that there is potential that using it to signify both those of unknown gender identity and those asserting a non-binary gender could lead to contention about these categories, as well as conflation of those who are non-binary.

**Museum:** As Ambrose and Paine (1993) point out, the concept of ‘museum’ is transient and develops over the time, but is held in the present by tacitly accepted ‘working’ definitions. Whilst I will explore more about what a museum is in the literature review, I present these definitions to provide a handle on the concepts until that point. The International Council of Museums (ICOM) define the museum as:
a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment. (ICOM, 2007)

However, in 2019, this was subjected to revision, with a split vote on the definition:

Museums are democratising, inclusive and polyphonic spaces for critical dialogue about the pasts and the futures. Acknowledging and addressing the conflicts and challenges of the present, they hold artefacts and specimens in trust for society, safeguard diverse memories for future generations and guarantee equal rights and equal access to heritage for all people.

Museums are not for profit. They are participatory and transparent, and work in active partnership with and for diverse communities to collect, preserve, research, interpret, exhibit, and enhance understandings of the world, aiming to contribute to human dignity and social justice, global equality and planetary wellbeing. (ICOM, 2019)

This led to the new definition being retracted and a future discussion being suggested. By contrast, the Museums Association (United Kingdom) defined a museum in a 1998 definition that it has retained:

Museums enable people to explore collections for inspiration, learning and enjoyment. They are institutions that collect, safeguard and make accessible artefacts and specimens, which they hold in trust for society. (Museums Association, n.d.)
**Gallery:** Within a museum there are many different spaces – cafes, rooms with objects and displays, toilets, corridors, spaces that are closed to the public, or offices that are for staff and museum personnel. I will be using the term ‘gallery’ in this thesis to describe permanent displays that are open access within a museum. In particular, I distinguish this from an ‘exhibition’ – a temporary display of materials within a museum.

**STEMM:** Throughout the thesis I use STEMM as an abbreviation for science, technology, engineering, mathematics and medicine. I use this acronym rather than STEM (without medicine) as there is a great deal of medical work within the space science field. Additionally, medicine relies on many of the same practices and knowledges as the other fields and is displayed in many of the same museums.

**Space:** Redfield (2000) describes space as having two important senses in projects like this one: one involving the realm of rockets and satellites and the other involving the geometry of human experience. To aid the reader, I shall be using ‘space science’ to denote the former, and ‘space’ to denote the latter.

### 1.5 Summary

In this chapter I have introduced the premise and guiding questions of the research. I have explored in relation to a Make-up kit the possibilities and shapes that a queer feminist methodological approach might open to thinking about displays in STEMM museums. In the next chapter I will explore the literature surrounding space science, museums, and learning in public spaces, as well as further addressing gender, sex, and sexuality in the context of a queer feminist piece of research. This literature review lays the ground for the methods I have used in this research. By the end of Chapter 3 I will have prepared the context in which to discuss the findings of the research in this thesis.
Chapter 2: Literature Review

Although this section of my thesis is entitled a ‘literature’ review, this is not where all the content in this section has come from. As Lather (1999) indicated, writing a literature review is an inherently political act – simultaneously both creating and defining the field in which my work is situated – and in this case the situatedness of my research has not only been within ‘scholarly’ literature. Understanding knowledge practices as expansive beyond the academy, in this chapter and elsewhere in my thesis I have drawn on academic texts, other text-media publications, audio content (e.g. podcasts, radio, talks), images, videos, social media, objects and artefacts, illustrations and other non-text communication, attending historic sites or museums, teaching resources, and personal communication. The chapter is structured around four themes: space science in context; museums; learning in public spaces; and gender, sex and sexuality. In all of these I span what might be considered ‘strict’ academic materials and an expansive reimagining of the academy that values knowledge from multiple sources, and I have tried to give an indication of the types of material that both contain in this thesis.

2.1 Space science in context

To critically engage with science through queer and/or feminist methodologies is not just to take “for granted that scientific data is the source of uniquely direct knowledges” and engage with the data through methodological situatedness, but also to challenge the premise of that statement to understand the “politics of science” implicit within the generation of the data (Willey, 2016b, p. 21). In my Introduction I have already covered some of the ways that queer (and) feminist enquiry can and has shaped research in science
studies more generally. In particular, these can be broadly be grouped into questions around knowledge production and the contexts in which that knowledge production occurs. Theorists including, for example, Giordano (2017), and Subramaniam and Wiley (2017) reimagine feminist approaches to science knowledge production as a site that permits democratic, decolonial, coalitional, queer, and antiracist approaches to science. Rejecting the naturalisation of ‘value-free’ decision making in science, including construction of, for instance, the ‘universal woman’ and ‘universal body’, allows expansion of what ‘science’, as a site of knowledge production, is permitted to contain.

Theorists have looked sociologically at the ways science initiatives are framed around gender, concluding that many that are geared towards the ethos that science should “include women” do so in ways that reinforce “uninspired, regimented, and conformist notions” (Subramanin, 2014, p.213), betraying an attempt to safeguard the establishment’s patriarchal, hierarchical, normative approaches to inquiry, personhood, knowledge production, and development of epistemic positions. Moreover, whilst features of science that rely on these establishment values such as community still play an essential part in the scientific capital that individual researchers might have (Joseph, 2020), we can argue that practices are still structured around an abstract hegemonic ‘Science’ (Harding, 1986).

Instead, feminist approaches to science studies might introduce plurality into how these spaces can be studied. For example, a naturecultural vision would open up further space for thinking about feminism as a site for theorising and reconfiguring the very meaning of science (Subramaniam & Willey, 2017, p.4)

Elsewhere, Rivers argues that the early twenty-first century is a generative time for feminist science studies because of the
creative and exploratory orientation toward feminist science-making ... more ambitious, more creative, more self-reflective, and more interdisciplinary in our praxis (Rivers, 2019, p.181-182),

with similar calls for using science and technology studies as critical pedagogy emerging in centres at other institutions happening simultaneously (e.g. Cipolla, 2019; STS Futures Lab, 2019). The contexts of knowledge production also provide a locus of understanding science, for instance, investigation of the modes of scientific professionalisation from norms of the research site to training of scientists; to the social contexts in relation to women, trans*, disabled, Indigenous, and scientists of colour has opened particularly fruitful research avenues for research. Research has addressed experiences of those with historic underrepresentation of genders both in the past and the present. In the following sections I shall take some of these expansive approaches to thinking through space science.

2.1.1 Who does ‘space science’?

Broadly understood, ‘space science’ is something that multitudes of cultures have undertaken and invested in across time and geography. Working against a tendency for neo-colonial practices of subsuming historic and contemporary Indigenous knowledge into the practices of western science (e.g. Ryan, 2008), I include plural and growing fields of scholarship on global sky cultures, understanding that across all functions, fundamentally, celestial phenomena should be viewed contributing to human societies as well as providing a specific context for a parts of life (e.g. Iwaniszewski, 2011).

Religious and spiritual practices have long been associated with the stars, including Egyptian lifecycles (e.g. Orofino & Bernardini, 2016), structures such as Stonehenge in south-west England (North, 1996; 2007), or the emergence of faiths such as Zoroastrianism (Blake, 2016), and knowledge of the sky passed down through oral
tradition in Aboriginal communities (de Napoli, 2018). Historically communities in Mesoamerica understood their worlds as “networks of interacting animated beings” (Milbrath, 1999), understanding the sky as undifferentiated from the Earth (Dowd & Milbrath, 2015), and continue to see its importance in their lived experiences (e.g. Duran, 2020). Systemisation, mathematization, and interpretation of the sky can be seen in Babylonian civilisations texts; the Maragha Observatory (directed by Nasir al-Din Tusi) and Taqi al-Din’s Istambul Observatory as part of Islamic empires; Siddhantas, texts found in what is now India – forerunners of Arabic Zii texts – that understood the patterns of the stars; and Christian empire observatories at, for example, the Vatican or Padua University.

However, there is a danger in characterising these as all equally ‘scientific’ – itself assuming an agreed upon definition of science. Western, Eurocentric science (grown, mainly, from the Christian tradition) is generally what is considered ‘science’ today, and exists alongside Indigenous science (Ogawa, 1995). Many of the practices described above are retained in contemporary cultures. Rather than positioning Indigenous knowledges of the natural world and Eurocentric science as oppositional, itself a colonial project that carries the subtext of winners and losers (Macedo, 1999), it is possible to think in many, plural, ways around their co-existence. Battiste (2000) suggests that recognising and restoring Indigenous knowledges is a healing action, and bridges can be formed between Eurocentric knowledge and Indigenous knowledges. Aikenhead and Ogawa (2007), for example, describe how this might be applied through introducing Indigenous ways of living in nature and neo-Indigenous ways of knowing nature alongside Eurocentric sciences in the science classroom. Rather than subsuming these ways of knowing as historicised precursors to Eurocentric ‘science’, it is crucial to allow Indigenous knowledges to be valued in their own right as important ways of knowing about the world, especially in the context of the sky with which so many cultures have a relationship.
### 2.1.2 Doing ‘space science’ in Outer Space?

Since the completion of the International Space Station (ISS) for habitation in November 2000, there has been a continuous presence of humans in space – arguably changing the relationship humans have with the places beyond Earth. As of April 2020, there have been 240 individuals from 19 countries that have visited the ISS (Garcia, 2020). This change in humanity’s presence in space has inspired approaches including archaeological research projects to look at the legacies of human spaceflight on the moon (Gorman, 2012), or on the International Space Station (ISS Archaeology, n.d.), as well as ethnographic projects on extra-terrestrial societies (Aiken, 2015).

While the ‘race’ to put humans in space has been framed as a display of military capability between the United States of America and the USSR (Agar, 2012), since then many other nations have demonstrated the ability to put both humans and technologies in space, including India (for example, Aliberti, 2018; Paracha, 2013; Sridhara-Murthi & Shoba, 2010), China (Harvey, 2013; Wu, 2017), Japan (Moltz, 2011) and the European Space Agency (Landfester, 2011). Space presence, through rocket launches, satellites in orbit, humans in space, or multiple other modes, has been theorised as “national signalling of technological and economic capability [that] can be expected to continue and contribute to the global development of space exploration” (MacDonald, 2017, p.213), and a sort of “geopolitical conspicuous consumption” (MacDonald, 2017, p.213) conferring status in the international arena, meaning that although political motives may be varied, there is:

an appreciation for the often overriding role that the signalling characteristic of space exploration has had in motivating expenditures can aid in defining small programs and projects that find political purchase. (MacDonald, 2017, p.212)

Indeed, sending objects and people to space costs not inconsiderable sums of money. Globally, these sums have a long history of being from both national and private sources, with “private funding ... [playing] a much greater role than [has] generally been
considered” (MacDonald, 2017, p.208). So, whilst national agencies such as NASA, ESA, JAXA, ISRO, or CNSA are often headline features in popular culture in a narrative of nationalist concerns of the space age of the twentieth century, projects like Space X (Elon Musk), Virgin Galactic (Richard Branson), and Blue Origin (Jeff Bezos) have been characterised as the return to the importance of private wealth in large scale (particularly USA) science research, stretching back to the 1840s with private financing of the American Observatory Movement.

2.1.3 Doing ‘space science’ on Earth

There are many books and papers written uncritically, and without theoretical framing about the work of scientists investigating Outer Space. Texts such as Remote and Robotic Investigations of the Solar System (Kitchin, 2017), Dying Planet (Markley, 2005), and Planetary Landers and Entry Probes (Ball et al., 2007) recount the details of missions to solar system locations that seek to expand human knowledge about the cosmos. Many, like Dreams of Other Worlds, detail admiringly the roles of these missions: celebrating for example “iconic space missions that have opened new windows onto distant worlds” (Henry & Impey, 2013). However, work by other theorists, including MacDonald (2007), has sought to establish Outer Space as a field that could be critically engaged with by geography and adjacent fields. These works understand that the “contemporary struggle over Outer Space is too serious to pass without critical comment” (MacDonald, 2007, p.593), acknowledging that while there are historical and cultural studies of Outer Space, moving this material firmly into the work of social science is also crucial to understanding how the area can be theorised. Thus, interdisciplinarity is a central feature of thinking through ways of engaging and understanding space science (Codignola-Bo & Schroggl, 2009).

Emerging studies of the International Space Station (ISS) that I referenced above are echoed in ground-based anthropologies of space science research sites. Research has
explored ground launch and development sites in French Guiana (Redfield, 2000) and Brazil (Mitchell, 2017), as well as telescope analysis of Chilean desert locations (Silva, 2019), the Square Kilometer Array in South Africa (Walker et al., 2020; Joseph, 2020), and national observatories of Latin America (Keenan, 1991). Increasingly, analogue sites, from Antarctica (O’Reilly, 2017; O’Reily & Salazar, 2017), to the deep seas (Helmreich, 2009) populate the literature, addressing how we can imagine or research unfamiliar, extra-terrestrial sites here on Earth. While many of these research projects explore sites in relation to the United States of America, there are some that address emerging space powers, including the growing presence of Chinese research infrastructure in Latin America (Klinger, 2018), and the concurrent developments of Indian and Chinese space programmes (Stroikos, 2016). The National Aeronautics and Space Administration (NASA) has one of the best funded space agencies in the world. Consequently, it is high profile and attracts (and can facilitate) much social science and historical research, including speculative oral history (Launius, 2003), theorising the development in relation to political shifts (Launius & McCurdy, 2018; Logsdon, 2019), and hosting sociologists alongside the programmes (Messeri, 2016; Vertesi, 2016). By contrast, the British space industry (and its involvement with and funding of the European Space Agency, ESA) has been both less well funded in post-war Britain (Macauley, 2012) and less well theorised (Millard, 2010).

These accounts echo more historical work on the roles of politics, defence and militarisation in shaping space. From understanding how the political entanglements of the Cold War and burgeoning space work shaped conceptions and actions in Space (Agar, 2012; Brandau, 2015) to thinking through how politics influence the design and function of space systems (Fries, 1988), there are multifarious implications of these fields on the scientific or technological work in space science. Indeed, the ‘race for space’ was shaped so strongly by a concurrent push for ideological territory on Earth that colonial attitudes continue to permeate the work done in the field, all the way through to understanding other planets in the context of Earth (e.g. Anker, 2011) – such that eventually ‘ecological
colonisation of space became tools for solving environmental problems on Earth” (Anker, 2011 p.239).

While large-scale instruments and organisations populate the headlines of space science, the actions, developments, and progress is attributable to the work of individuals who work on these projects. Sociologists have worked on the ways that STEMM professionals produce knowledge. Consequently, researchers can describe and discuss the functions of organisation through, for example, communities (Knorr Cetina, 1999), collaboration on projects (Shrum et al., 2007), and collectivist technologies (Turner, 2005). Particularly relevant in space science communities are theorists working on issues to do with remote instrumentation (Goodwin, 1995; Helmreich, 2009; Hutchins, 1995), the relation of researchers to these pieces of technology through, for instance, embodiment of the technology that collects the data of study (Myers, 2008; Vertesi, 2015) or anthropomorphisation (and its inverse, the technomorphisation of human bodies in relation to them) of technologies. This anthropomorphism takes not only a ‘general’ human form, but rather specific human characteristics; for example:

-the robots even have social class: during my ethnography, Spirit was frequently described to me as a ‘blue collar’ laborer who had to work for every success she earned, while Opportunity was a ‘golden girl’ who found evidence of water on Mars immediately after landing. (Vertesi, 2012, p.399)

Not only assigning the robots a social class, the two Martian rovers are gendered female as well. This is not unusual, the anthropomorphisation of these particular robots takes place in the lab, as seen here, as well as in engagement with publics on social media, for instance in their engagement on Twitter accounts (Vertesi, 2010). Szücs (2015) looked at the Twitter feeds of the spacecraft duo Rosetta and Philae and documented the gendered relationships of spacecraft, that characterised Rosetta as a maternal, female, carrier, and caregiver. Philae, by contrast, was variously her masculine son or lover, who took the ‘first
steps’ onto a comet. This is not a new to robots of space science. Bimm (2013) detailed how the first USA primates in space were shaped by their times of death. Abel, who died shortly after her flight in space, was taxidermised and housed in the Smithsonian, where she later appeared gendered masculine in *The Night at the Museum*, whereas Baker, who lived for many years after the event, was known as ‘Miss Baker’ with a number of unsuccessful ‘monkey husbands’, was repeatedly and ongoingly gendered feminine.

Indeed, it is not just the robots that are part of space science research that take on specific, intersecting, identities, but the communities of research themselves. Researching gender and sexuality in physical science communities, even in the very recent past, has revealed the unchanging “implicit and explicit messages about the masculine nature of math and science” as ongoing problem (Shapiro & Sax, 2011, p.12). These narratives continue to “[reinforce] particular expectations of masculinity and can limit gender expression possibilities” (Yoder & Mattheis, 2015, p.4) – i.e. continuing to inform overwhelmingly normative communities. While a USA study about being ‘Queer in STEM’ suggested that “participants working in STEMM fields with better representation of women reported a higher degree of openness” (Yoder & Mattheis, 2015, p.21), this did not significantly improve the experiences of queer physical scientists. Other reports have demonstrated that such scientists were more likely to leave the field after undergraduate study (Hughes, 2018), and that the same desire to remain not-‘out’ is found in UK physical science literature too (Institute of Physics et al., 2018).

Researchers show that underrepresented genders across the board experience marginalisation (Etzkowitz et al., 2000). During the 1960s-1980s, space community has been understood as inherently gendered at NASA (Hilck, 2019). Today, there are still few researchers who identify as women on mission teams at NASA (Rathbun, 2017); though the number is slowly increasing with time but is still not on a par even with the underrepresentation of women in space science more generally (nor with even more serious underrepresentation of women of colour, or non-binary folk; see Rathbun et al.,
2020). This bleeds through into belief about belonging: in STEMM degrees across the board, women have lower self-efficacy despite achieving higher grades than men (Whitcomb & Singh, 2020).

Research shows that marginalisation is compounded for women of colour in STEMM higher education, who find themselves in a double bind (Ong et al., 2011) against the masculine, white construction of the scientific academy. There is significant, and growing, research demonstrating the development of counter spaces (cecil, forthcoming; Ong, 2018), and rejection of white norms (Prescod-Weinstein, 2017) specifically by and for women of colour in STEMM; and that these practices take place in a range of locations, including in publicly available spaces such as Twitter activist work on #spacewoc (for example, Persaud, 2020), #BlackInAstro (for example, Walker, 2020) and podcast Melanin Memos (Abeyawardene, 2020).

2.1.4 Doing ‘space science’ in popular culture

Since around the late 1800s going to space has been the subject of discussion in the western public and scientific arena. Rieder argues that once the world had been circumvented, western literary speculations moved to the deep oceans and out to space (Rieder, 2008). For instance, Jules Verne’s visions of Twenty Thousand Leagues Under the Sea (1870/1872) and From the Earth to the Moon (1867) tie together these occupations of the late nineteenth century. The literary development of space science fiction (in the English language), which predated any actual space exploration, has the contextual history of British colonialism and imperialism. These science fiction constructions carry with them these biases, resulting in “utopian and satirical representations of encounters between European travellers and non-Europeans” (Rieder, 2008, p.2), and include “allusions to colonial history and situation” (Rieder, 2008, p.3) as a part of their plots and motifs, nested within the science fiction novel – itself inseparable from “imperialism [and] unthinkable without” it (Said, 1979, p.71).
Colonialism, as an ideology, or set of ideological fantasies (Žižek, 1993), can be seen manifested as a set of linguistic turns (Shaw, 2008). Linguistically, space science phrases that draw from colonial narratives set this research and future work up as exclusive to an in-group. For instance, the ‘final frontier’ draws on descriptions of moving west in building the states in America, implicating a *terra nullis* fantasy of the land being empty, despite the acknowledged presence of Indigenous peoples. Across media, as I will illustrate later in this thesis:

American history [is] a straight line, a vector of inevitability and manifest destiny linking the westward expansion of Anglo-Americans directly to the exploration and colonization of space... advocates of U.S. spaceflight have created their own frontier mythology, as Limerick has noted, expanding the story of Western American settlement to encompass space exploration. (Billings, 2007, p.487)

The Space Race, getting humans into space and onto the Moon, is steeped in national and political discourse. But it is not only the politics of nation that plays out in this discourse. Discourse framing the ‘final frontier’ or the ‘emptiness’ of space should be closely interrogated – especially when thinking about constructing imaginaries of space science. After all:

[from a colonial perspective, both interplanetary space and the lands of ‘primitive’ people are *terra nullius*, empty wilderneses, or moral vacuums, into which civilized sea-faring or space-faring nations can bring the right moral order. The colonial aspects of space exploration are a mirror of those same aspirations played out on Earth. (Gorman, 2005, p.99)

The ‘pinnacle’ of the Apollo missions to the Moon, argues Gorman, was not that men went to the Moon, but that the missions allowed Americans to “imprint a specific
national, ideological and colonial meaning on the Moon” (Gorman, 2005, p.102).

Discussions about science in planetary science context might not be happening in relation to lands on Earth, but just because it is about “somewhere like Mars, it’s still not OK to use those narratives, because it erases the history of colonization here on our own planet” (Walcowicz, quoted in Zeitz, 2018). Correspondingly:

> Every one of the 12 humans to set foot on the Moon has been a white American man. Just one in 10 countries on Earth has sent an astronaut to the International Space Station, and only three countries in the entire southern hemisphere have been able to do so. The U.S. sent its first Native American astronaut to space in 2002. Those statistics and the loaded terminology we use to talk about space are two sides of the same coin. (Bartels, 2018)

Although Bartles, Gorman, and Walcowiz are talking about the language and discourse surrounding ‘space science’ missions, as I alluded to at the start of this section, the science is never in isolation from expectations set up around these projects through cultural discourse.

Colonist narratives pervade not just ideas about property rights in Outer Space, but also bleed into the ‘proper’ roles that people have in these futures too. Science fiction theorisation has taken steps towards understanding the changing characterisations of genders, sexualities, and their intersections. Some theorists argue that most popular science fiction since the 1970s is characterised by the motif that:

> Speculation about social institutions and individual psychology has always lagged far behind speculation about technology, possibly because technology is easier to understand than people. (Russ, 1971, p.201)
Further than just recapitulating the existing gender roles in science fiction, Russ contends that many formats take “idealized and simplified” (Russ, 1971, p.202) gender roles of an idealised, white, western twentieth century as their starting point, including depicting women as prizes, women as supernaturally beautiful, women as weak – such that “masculinity equals power and femininity equals powerlessness” (Russ, 1971, p.203). Gender, it appears, is uncomplicated in Russ’ analysis. Setting out an idea of ‘woman’ as the opposite of ‘man’ depicted in science fiction without a challenge to the possible innovations of plural genders, their relationships with biological sex, or other identity formation perhaps serves to re-inscribe a binary gender in the analysis itself. Some science fiction writers – most notably Ursula Le Guin (e.g. *The Left Hand of Darkness*, 1969; *The Tombs of Atuan*, 1971; *Coming of Age in Karhide*, 1995) – do trouble and challenge these ideas, but such work has been uncommon in the canon.

Rather than being completely speculative fiction, a significant quantity of science fiction is produced in conversation with scientific ‘experts’. For instance, Telotte (2008) details the introduction of an early Disney production *Man in Space* that relied on articles and words of space science experts of the time such as Wernher von Braun. In the selection of the experts, the titles of the pieces (*Man in Space*, 1959; *Man on the Moon*, 1955), and their animators themselves, these shows build a discourse of American masculinity, that creates a “sense of empowerment” (Telotte, 2008, p.54) for particular members of the audience, reinscribing gendered norms about space. Although Telotte’s anlysis about gendered norms was investigating early twentieth century films, it could equally have been talking about any number of films that were released in the Summer of 2019, marking the 50th Anniversary of the Apollo 11 mission to the Moon, many of which appealed to the same mythic narratives of masculinity.

Publication of a 2010 anthology, *Queer Universes*, marked an analytic turn that was explicitly queer (Pearson et al., 2010). To that date, some disparate work had been done on sexuality in science fiction (Garber & Paleo, 1983; Hollinger, 2002; McKinley-Portee,
2017; Pearson, 1999), although a sustained and cohesive body of theorising did not exist. Thus, the analytic turn demonstrates that science fiction pluralises the varieties of worlds that are possible suggesting, as Kilgore expresses, that “we can imagine futures in which our descendants differ profoundly from ourselves while existing with us in a shared history” (Kilgore, 2010, p.234). By drawing into the analytic fold queer, feminist, afrofuturist, and disability-focused texts that otherwise challenge hegemonic binaries, it is possible to use them as counterpoints to explore what queer means in science fiction and how it can be produced, constructed or understood in its readings.

Wälivaara (2016) extends these arguments beyond science fiction texts into films and television shows. Wälivaara argues that in more recent (twenty-first century) pieces, television has been able to challenge and change the heteronormative status quo, while cinematic science fiction has struggled to do so. Citing cases of *Star Wars* (the television series, not the films), *Star Trek, Firefly* and *Torchwood*, the ability to create and tell stories about queer characters in television has allowed a move away from a generic understanding of science fiction. By contrast, drawing on the same canon of science fiction shows, other theorists have challenged exactly how what the queer plotlines these shows construct tell us. Demonstrating a resurgence of a motif of queer encounters happening in, for example, a parallel universe, cybernetic counter-world, or ‘queerverse’, ‘queer-baiting’ (creators hinting at, but not depicting, same-sex romance or other LGBTQ+ representation) or the tropes of ‘bury your queers’, have reappeared, leading to argument that these television shows perhaps demonstrate an alternative, but rarely significantly challenge or reshape mainstream cultural narratives about heteronormativity (Kozak, 2018).

Perhaps sexuality norms are not as explicitly queered within cinematic presentation, but gendered expectations have experienced some challenges since the early 2000s. For example, *Hidden Figures* (2016) details the lives of three women of colour in the United States programme to get a man into space. Rather than having their lives as an adjunct to a
central white male narrative of getting into space, this film (based on a book with the same title, Shetterly, 2016) explicitly centres the lives of Katherine Johnson, Dorothy Vaughan, and Mary Jackson – their work, their families and relationships, and their triumphs. Not only does it challenge the single isolated white male genius narrative so common in narratives about space science by showing collaborative practice of Black women, all individually undervalued by NASA as a result of their identity, but it also gives a new feminist telling of these stories that sees their lives as central, valuable, and worthy of exploration. 2019 saw the release of Mission Mangal, a Hindi-language film loosely based on those involved in the Indian Space Research Organisation who worked on the Mars Orbiter Mission, with emphasis on the lives of seven women in the team that lead the programme. However, both films are replete with constructions of national narratives about the place of science within a (gendered) national identity. There is, however, little or no space within these films for gender identities that fall outside the binary divide, something that I only hope will be expanded in the future.

Famous in her own right, Hidden Figures’ Mary Jackson was played by Janelle Monae, whose work developing alternative narratives about space science and technological futures is part of musical popular culture. Tracks including Ride, Sally Ride, and her album Dirty Computer (2018) develop ideas about what a space future might look like, blending afrofuturist notions of futurity and possibility with technological nuance and knowledge, creating music as a mode of argument. Celebrating Sally Ride in a Black queer feminist album may tell us as much about the commentary on queer STEM work as much as any discussion on talks or films. The Moon exhibition at the National Maritime Museum drew explicitly on the use of music as argument, including Whitie’s on the Moon (Heron, 1970) a counterculture song detailing frustration of the USA spending on the space race and not on their Black population. Music has also been a signaller of the colonial attitudes to space ‘colonisation’ described earlier in this section. Missions sent with cultural markings, such as Voyager’s Golden Disc that contained audio content described as ‘music’ from white western cultures and ‘sounds’ often from non-Western
performers of colour, who were not identified by name (but their – white – recorders were), on the record perpetuates an idea about what counts as knowledge and culture in a space-faring future (NASA, 2019).

Different understandings of what space ‘is’ exist, not only in different times, but in different geographies. European Astroculture, as explored in Geppert’s edited volumes (2018a, 2018b, 2020), suggests that there is geographical specificity to these narratives and imaginaries – but also that there is such a thing as a ‘European’ conception of space. However, to critically address what is meant by ‘European’ is central; these texts do not speak to (and are not spoken by) the experiences of those with multiple, cross-continental identities – shaping what is communicated as the proper scope of ‘Europe’. In this thesis, I shall think critically through who is being included in the construction of space science narratives and imaginaries.

2.2 (STEMM) museums

That the contemporary ‘museum’ has so many different forms and functions makes understanding what a museum is a difficult project. In 1942, Low had already articulated that professionals and theorists struggled with the term ‘museum’ because of its many and various meanings. Over 60 years later, Anderson et al. (2011) wrestled with the same challenge, and came to break down Global North museums’ functions into five roles: public narratives, exhibitions, programmes, collections, and leadership. However, there are many ways of combining and exploring these ideas of conceptualising a museum.

A historic perspective on STEMM museums directs thought towards museums as spaces for educating and developing scientific knowledge (Moser, 2006). Natural philosophy museums, such as London’s Natural History Museum, became spaces where scientific studies and developments were not only made, but also legitimised in a public facing
collection. The interaction in the museum was strictly socially coded – with gendered, racialised, classed, and educationally stratified access to the material items of the collection (Candlin, 2008; Chaterjee, 2008; Schiele, 2008). As Das and Lowe identify, these museums also played an invaluable “ideological role” (Das & Lowe, 2018, p.6) in their contemporary societies, highlighting Dias’ work that demonstrated the role of craniological displays that both “increased knowledge of craniology ... [and] legitimised the process of scientific thought at the same time” (Das & Lowe, 2018, p.6). Friedman (2010) and Schiele (2008) suggest that the contemporary STEMM museums find their roots in world fairs, academic research and collections, and public demonstrations of science such as at the Royal Society and Royal Institution where spectacular demonstrations, automata, and experiments popular in the public realm were then folded into museums, exemplifying their educative potential.

Other theorists locate museum development in the object, as well as the collection, conservation, and display of these objects. Understanding the museum through the objects collected also sheds light on the history of the institution. For instance, Pearce (1994) suggests that studying collections (rather than objects themselves) gives an understanding of objects that exist outside the collection, the entry of objects into the collections, and the purpose of collections themselves; in turn giving a much better understanding of “notions of what creates value” and therefore is worthy of collection at any given time. This links how these ideas “are the related processes of social change and the relationship of the material world to these movements”, understanding “how and why [objects] have meaning as they come and go in use” (Pearce, 1994a, p.4). Such theorisations build on ideas about societal interaction of world systems (Appadurai, 1985) – emphasising that it is not just the individual interaction with an object, or ‘thing’ that constructs its social meaning, but that the object has a social life: a web of meaning around and between the social constructions of objects.
Tensions between displaying the social context, the function of the object, or the aesthetics of objects are particularly rife in STEMM collections (Gauvin, 2016). As many objects were functional equipment rather than aesthetic objects to begin with, discussions about the possibility of an ontological shift of the purpose of the object (or artefact) based on the perception of the artefacts themselves within science museums are ongoing (Nicolescu, 2016). It is certainly the case that the context and mode of display shapes the interpretation; indeed, Vogel’s *Art/Artifact* exhibition (1988-1990) pivoted around this concept, with four displays of artefacts from the African material anthropology collection, to encourage visitors to reflect on the “received wisdom and the rhetorics of museum strategies” (Faris, 1988, p.775) in developing ontological and epistemological arguments about objects. This focus on objects, however, is revealing of an emphasis on being able to talk ‘for’ objects:

[it became] more and more difficult for Western scholars to make authoritative claims about other people, as colonized or otherwise disempowered communities throughout the world challenged the right of anthropologists to study them ... as human subjects increasingly protested against being treated like objects – anthropologists began to explore the advantages of treating (non-human) objects like (quasi-human) subjects. (Fowles, 2016, p.12)

Particularly crucial in thinking through anthropological collections, Fowles is critical of Appadurai (1986), Clifford (1986), Latour (1993), and Miller (1987); through their posthuman subjectification of objects – asking not what things mean, but what they do – Fowles argues that the language of imperialism and the subaltern bleeds through into these object-centred arguments. Here, Eurocentrism has simply been reconfigured as Anthropocentrism, flattening inequalities between humans, making all humans equally tyrannical or imperial and creating “[o]bjects [as] very convenient subaltern subjects” (Fowles, 2016, p.23).
Rather than focusing on objects, with the rise of ‘big science’ interrogation of which concepts on display, where and how, are a growing area of development. Hubber (2006) defines concepts as “socially negotiated meanings given to terms or processes constructed by individuals to interpret interactions with the physical world” (Hubber, 2006, p.420). This meaning is worked against terms such as ‘models’ which, according to Gilbert (1995), are representations of objects, events, processes, or systems, and ideas which Grosslight et al. (1991) understand to be knowledges about reality that are learned from the model. In this section I shall be using the term ‘concept’ to understand a scientific principle or idea rather than a physical object.

Frequently, concepts are positioned as challenging to display as they cannot often be represented in museums well due to their abstractness. Much existing research on the display of concepts focuses on the difficulty and challenges of displaying evolution (Diamond & Evans, 2007; Diamond & Scotchmoor, 2006). For instance, different graphical displays of cladograms in museums (MacDonald and Wiley, 2012) can shape the interpretation of the content and the understanding of the relationships seen in the tree (e.g. Giusti & Scott, 2006). Better established is the impact of ‘tree diagrams’ represented in formal learning environments (Baum et al., 2005; Gregory, 2008; Meir et al., 2007; Novick & Catley, 2007) and emerging scholarship suggest the same impacts are also seen in informal science settings.

Significantly less research on the display of concepts has taken place in the context of physical science museums. Space science, as a subject area, is rife with concepts – including distance, time, gravity, temperature, radiation, and energy. Where literature examines deep time or deep space (Cotner et al., 2009; Dodick & Orion, 2003; Jones & Taylor 2008; Trend, 2010), physical scale (Wormald, 2017), large numbers (Karlstrom et al., 2008), astronomical scales (Bakas & Mikropoulos, 2003; Kalkan & Kiroglu, 2007; Posner et al., 1982; Vosniadou & Brewer, 1992; Zeilik et al., 1998) and relative motions
(Rosvick, 2008; Yu et al., 2017), these issues are often tackled in the context of the classroom rather than in the context of the museum display.

Elsewhere, and as a ‘complement’ to the classroom, science museums are theorised as centrally being locations of (informal) education. Discussions cover variously who is constructing the education, and approaches to understanding education in the museum, and who the education is for. I argue that the educational programme of the museum encompasses the whole museum. Thus, while some theorists have located the construction of the ‘curriculum and pedagogy’ of the museum to be in the hands of the curators (e.g. Macdonald, 2001), or in the hands of ‘Learning Departments’ at institutions (e.g. Motto, 2016), I argue that we can see educational programmes of museums “function in the form of a chain” (Foucault, 1980, p.98), rejecting this happening at a single site in the museum, but rather distributed and co-constructed by all members of the museum, visitors, and the physical or digital resources the museum operates.

Whilst the public understanding of science (a didactic model of one-way communication from the ‘scientist’ to the ‘public’, covered in more detail in Section 2.3.2) is often critiqued as not allowing space for the publics’ own knowledges to be valued, many educational theorists would also argue that even in traditionally didactic spaces like museums, knowledge is always co-constructed with the learner. Dawson et al. (2019) worked to develop a theory of how information in museums is processed by visitors, centring the experience of the visitor in the museum learning environment. Dawson’s work, as well as that of other researchers (Crowley et al., 2001; Currie et al. 2007; Gee, 2000; Ramey-Gassert et al., 1996), emphasises performative identity (Holland et al., 2001) and co-construction of knowledge between visitors (Francis & Paechter, 2015) in a science learning space.

Museum studies is awash with discussion of the ‘ideal visitor’ (e.g. Falk & Dierking, 2012) – the person for whom the educational experience at the museum has been developed to
suit. This may be congruous (but not synonymous with) the ‘typical visitor’ the museum (Lindauer, 2006). Often, museums have undertaken audience research themselves to understand who visits the museums, and to construct an understanding of their ‘typical visitor’ – “the average of all visitors in terms of education, socioeconomic status, racial or ethnic identity, and previous museum experience” (Lindauer, 2006, p.204). Falk (2016) has worked on frameworks for understanding who visits the museum by situating the motivations of those who already attended the museums at which the studies were undertaken. Dawson (2014, 2019) argues that this work focuses only on those who do already attend the museum, and thus draws more of the same people into the museum by creating exhibitions for the same people, rather than expanding the audience to those who at the time do not see the museum as being ‘for me’ or ‘for us’. Inherent in the ideas of the ‘ideal visitor’ to science museums are intersectional problems of gendered (Archer et al., 2012; Walkerdine, 1990), racialised (Jennings & Jones-Rizzi, 2017; Ong et al., 2011), classed (Wong, 2012), queer-phobic (Sandell et al., 2018) and ableist (Hehir, 2002; Rieger, 2016) norms.

Gender identity has been a site of discussion and analysis for a considerable period of time (I discuss the problematisation of gender and sex further in Section 2.4). Tan et al. (2013) explore the ongoing and relentless alignment of science with masculine identities, cultures and practices – which in turn creates an identity dissonance between the girls/women (especially those of minoritized backgrounds) and science. In their exploration of physics, Archer et al. focus on the trials of identity formation in wanting to study physics in particular where “women struggle to be recognized simultaneously as both competent physicist and women” (Archer et al., 2017, p.91), and are significantly under-supported in their desire to study physics by teachers, family, or society at large (e.g. Danielsson, 2012; Faulkner, 2007; Mujtaba & Reiss, 2013). This disparity within physics identity confirmation in young people is particularly important to my thesis as it speaks to the allied specialisations that are in space science – engineering, cosmology, astronomy, robotics, geophysics and rocket science. It is not just that it is tricky for the
individuals to navigate these two identities, but that both male and female higher education students construct femininity, or being a ‘girly girl’ (Gonsalves, 2014), and physics as oppositional and incompatible. The majority of the literature (including the works cited here) that is about studying subjects such as physics; the division is between male and female sexes, which are mapped directly onto ‘masculine’ and ‘feminine’ gendered performances, and the subversion thereof. I will return, in Section 2.4, to explore and problematise these approaches.

These dissonances between gendered identity and the narratives and imaginaries of the museum bleed through into the visitor experiences in museums. As documented in Dawson, the gendered performances of girls in museums is strongly shaped by the materials present that represent them: forcing performances that variously fit the masculinity and whiteness the museum imposes; affect the ‘goodness’ in occupying the correct role that is designated for those not white or masculine; committing to silence in the space; or being ‘cool’ (Dawson et al., 2019). My thesis does not explore the responses of visitors to the exhibitions; however, it carries with it the exploration of the possible identities that can be found in the museum and how they may shape the identities that can be confirmed within the space.

2.2.1 Structural inequality in (STEMM) museums

Museums are theorised as key sites for informal science learning (which is also variously termed Public Engagement with Science (McCallie et al., 2009) or everyday science learning (Dawson, 2019)) where science learning can take place in informal contexts (Osbourne & Dillon, 2007). The science displayed there is always embedded in the context of the society in which the museum happens, such that power structures, divisions and biases from broader society are also present in these galleries (Longino, 1990). In particular, these informal science contexts privilege some groups over other (Gilbert & Mulkay, 1984; Latour, 1987; McNeil, 2007), as well as prioritising their social
and educational outcomes (Bucchi & Neresini, 2007; Edwards, 2004; Falk & Dierking, 2000; Mortensen, 2011; Packer & Ballantyne, 2002; Rowe & Frewer, 2005; Stocklmyer et al., 2010). In the literature across museum studies and science communication, there is some disagreement about what is or can be learnt in these spaces, understanding the limitations of learning opportunities in a single location (Macdonald, 2001) or arguing that learning only happens over time at multiple locations (Lemke, 2000; Rahm, 2004; Wortham, 2008). Understanding these problems through a lens of structural inequality in the museum helps move the discussion away from thinking of inclusion as special practice that is done in some places, to framing it as good practice to be undertaken all the time (Golding, 2009; Lynch, 2011; Sandell, 2007).

Understanding this role of structural inequality allows understanding that science museums, along with other locations of informal science learning, are able to dictate what ‘counts’ as science, describing “practices and artefacts as belonging to the proper realm of ‘science’, and as being science that an educated public ought to know” (Macdonald, 1998, p.2). Importantly, as Duensing (2006) points out, these informal science locations reflect cultural norms of a society, and as such prioritise their ideas about ‘correct’ science too, overlooking practices from, for example, working class (Taylor, 2016) or non-dominant ethnic groups (Bhopal, 2018; Gilroy, 2002; Levitas, 1998) as being ‘correct’ and worthy of display. Not only are museums exclusive in their delineation of science (Fleming, 2002; Reay, 2004) but they are also only partially public, primarily drawing a wealthy, white, educated demographic to their sites. Thus, informal science learning reproduces social inequalities (Bourdieu, 1984; Fleming, 2002; Lynch, 2011) because it favours those who are able to navigate and understand the practices prevalent in the museums, which in themselves favour culture and practices from the dominant group. These acts of symbolic violence (Bourdieu, 1991) obscure the reproduction of classed inequalities through decisions about what is displayed. Indeed, whilst Bourdieu primarily thinks about symbolic violence on a class basis, intersectional work (Collins, 2000) urges approaches that include thinking about the multiple marginalisations that occur through the
intersections of social class with, for example, gender, age, and ethnicity (Bennett et al., 2009; Dumais, 2002; Mickelson, 2003; Reay, 1998; Trienekens, 2002). Indeed, these intersectional categories have themselves been challenged as unified: vital anti-essentialist theories of class (Lucas & Beresford, 2016), ethnicity (Bhabha, 1995; Hall, 1996a; Jenkins, 1997); and their intersections frame these plural categories as a mix of social and cultural practices. Holland et al. (2001) do particularly vital work to bridge Bourdieu’s static conception of classed exclusion, and anti-essentialist ideas of these categories.

Secondly, structural inequalities frame the problems as being located with the institution, and as such, actions should be taken to counteract their exclusive practices (Sandell, 1998; Tlili et al., 2007). This runs counter to early twenty-first century practices of ‘outreach’ done by museums to bring ‘in’ non-dominant groups. Such practices have, Leong (2013) argues, made this inclusion into a tick-box exercise that white institutions do while continuing to exclude visitors of colour. The ‘outreach’ narrative also positions the groups rather than the informal institutions as being at fault (Dawson, 2019; Yosso, 2005), and this shift of blame onto ethnic minority communities, Bhopal (2018) argues, is a characteristic feature of racist societies. Moreover, this exclusion and ‘blame’ of groups that are non-dominant is gendered as well; for example, Phipps’ (2008) 30-year metasurvey of women in STEM programmes (many of which take place in informal science settings) in the UK found that they sought to change the attitudes and behaviours of women rather than seek structural change in scientific establishments. These projects (and the act of shifting blame) are symptomatic of an assimilation approach (e.g. Bell et al., 2009; Falk et al., 2015; Fenichel & Schweingruber, 2010). Those who are not included are perceived to lack knowledge, and fail to surmount ‘barriers’ to entry, such as the cost of entry to museums; thus, it is the fault of non-participants rather than exclusionary practices of museums that are off-putting and limit the audience. Efforts in outreach focus on these perceived ‘barriers’, such as the cost of entry. However, for instance, national museums in the UK have been free for over 20 years, but the removal of this ‘barrier’ did not result in a greater diversity of visitors to the museums (Ipsos MORI,
2003, cited in Dawson, 2019). This example demonstrates how a focus on a perceived barrier of entry (cost or distance to the site) obscures the need for changes in “hiring, content development, representation” (Dawson, 2019, p.42). In fact, the delineation of the dominant culture as being the important knowledge (particularly as museums are developed by and suited to these groups) makes these sites structurally unequal in terms of the cultures they house, and it is these cultural differences that have been identified as a strong driving force of non-participation by non-dominant groups (Aikenhead, 2002; Fenichel & Schweingruber, 2010; Roth, 2008). It is imperative to understand that these racist, gendered, classed and ableist practices happen at the level of people employed by the institutions as well as institutions themselves (Dawson, 2014; Gilroy, 2002).

Much existing work focuses on those who already participate in these informal science contexts, and the skills and knowledge that the participants learn and develop. This has been criticised as being inward looking not outward looking; Ash and Lombana (2011) argue that “relying so heavily on only a narrow slice of visitor representation for normative purposes is misleading at best, and inaccurate at worst” (p.3). Thus, museums continue to evade problematisation, with theorisation only being about those who already attend and now those who are absent such as disadvantaged socio-economic groups, working class and minority ethnic groups (McPherson, 2006).

STEMM museum, therefore, sit at the cross-currents of problematising museums and problematising science. Museums, theorised as institutions of white privilege (McIntosh, 1989), provide many positive stories about white people and this overrepresentation is seen as normal. Museums also tend to be institutions of cultural imperialism (Karp, 1991; Onciul, 2015) that mark knowledge, practices, and selves as Other. Science is itself all too often structurally problematic (Cassidy et al., 2016; Medin & Bang, 2014; Pollock & Subramaniam, 2016; Schiebinger, 2007) so it is urgent to challenge the intersection of these challenges rather than treating these problems as separate.
2.2.2 Activism in the museum

While much of this thesis looks at theorisation of actions that take place outside of the academy, it is important also to think about how these activist practices work within academia, as actions of museum professionals are interwoven and develop concurrently.

2.2.2.1 Social justice and museum activism

Social justice, in its multiplicities, can been theorized as a process that begins with

an examination of how dominant and non-dominant conceptions of justice arise; how they are selectively institutionalized; how they are formally and informally applied; what persons and/or groups are being deprived of its formal mandates; and how, finally, to correct deviations so that justice is served. (Capeheart & Milovanovic, 2007, p.1)

Social justice as process relies on an understanding of the concept of ‘justice’ – something which historically may have been constructed from above (by the elite) or from below (by the many). Justice will look different to different actors, and on different concerns; it should be acknowledged to change over time: what looks like social justice at the time I write my thesis will not necessarily look like social justice in a different time or a different place – social justice work recognizes an “ever-evolving society without ever being committed to a static conception” (Capeheart & Milovanovic, 2007, p.2). Importantly, social justice looks at allocation of rewards and burdens (distributive justice), how to resolve disputes and allocate resources (procedural justice) and how to respond to harm that has been caused (reparative justice). Unlike the criminal justice system, social justice thinks not only about what a just reaction to a harm in isolation is, but contextualizes the harm to understand if the reaction is just in relation to the ‘harm’ in a (non-static) society. In order to understand what a just reaction might be, it is also key to understand the harm being perpetrated. Social justice can be traced through theories of justice (see, for
instance, Capeheart & Milovanovic, 2007, p.11) and is situated at the heart of a number of contemporary museum movements, including, for example, postcolonial (e.g. Osler, 2015), queer (e.g. Sulivan & Middleton, 2019), and feminist (Calihan & Feldman, 2018) movements. In this thesis it permeates my understanding of both museum theory, and education.

However, Tuck and Yang remind us that it is important not to conflate social justice with decolonization – “decolonization wants something different than those other forms of justice” (Tuck & Yang, 2012, p.2). Decolonisation unsettles – breaks without compromise (Memmi, 1991) – the relationship of “settlers-native-slaves” (Tuck & Yang, 2012, p.17), where the settler, or colonizer, is positioned as “both superior and normal; the settler is natural, whereas the Indigenous inhabitant and the chattel slave are unnatural, even supernatural” (Tuck & Yang, 2012, p.6), not just “for everyone to merely swap spots on the settler-colonial triad” (Tuck & Yang, 2012, p.31). Social justice can operate whilst maintaining the superiority of particular groups, but challenging who constitutes which position on the triad.

One way to understand the need for reparative or distributive justices is to think critically about the systems form which justice is sought. To move from the ‘outside’ to the ‘centre’, within the context of society, we should think about the construction of the ‘outside’ in the first instance. This can be seen in the constructing the ‘Other’. de Beauvoir (1949) claims that it is “a fundamental category of human thought” (de Beauvoir, 1949, p.xix-xx), with Minh-ha arguing that ‘Oneness’ is never independently constructed, but rather comes from the contrast with a silent, binary other (Minh-ha, 1991).

These arguments assert that, historically (and one might argue, in the present as well) the One is men – constructing women as Other; or the One is whiteness, constructing Otherness as being a person of colour. Introducing a queer critique, this binarization of
‘One’ and ‘Other’ by de Beauvoir overlooks how One-ness is constructed along multiple axes, making ‘others’ who are not all equally ‘othered’. As an example to demonstrate this, I take the example of problematic panels I have witnessed and been invited to sit on, where individuals are by one ‘other’ – white gay men, straight men of colour, white disabled men, white straight women. Each is only one step removed from the ‘One’ of western systems, the idea of intersecting identities that create ‘othered’ others is often not well developed in such settings and thus important views remain excluded from discourse. hooks takes this construction of the One, and moves it from de Beauvoir’s theorisation about constructing actions that make “the One [while] at once setting up the Other over against itself” (de Beauvoir, 1949, p.6) as an act by men against others, and situates this marginalisation as a problem of the societal system of the patriarchy:

Patriarchy is a political-social system that insists that males are inherently dominating, superior to everything and everyone deemed weak, especially females, and endowed with the right to dominate and rule over the weak and to maintain that dominance through various forms of psychological terrorism and violence. (hooks, 2004, p.18)

Thus, hooks situates the problem of oppression on us all as “[w]e are all socialised in this system”, and asserts that systematic patriarchy “shapes the values of our culture” (hooks, 2004, p.1), building on Real’s assertion that the patriarchy is damaging to us all (Real, 2002). Thus, the patriarchal ‘One’ and the ‘Other’ become categories that we all perpetuate and must work to do distributive or reparative social justice work against, addressing both the harms caused and the social context in which they occurred. Further to this, scholars have developed more detailed arguments about what could be considered the ‘One’ specifically within the museum context. For example, Said considers the West to occupy the category of the ‘One’ (1993), Spivak considers the voices and language of colonialism (2008), and Sandell considers the heteronormative (2007).
To think critically about how we ‘repair’ or ‘reconstruct’ these ideas about identity, I believe it is vital to consider how multiple marginalisations intersect to ensure that any social justice being proposed does not serve only those mostly closely adjacent to the category of the ‘one’ as it stands. Kimberlé Crenshaw, working on legal contestation of sexual harassment, described how Hill, the defendant:

was rhetorically dis-empowered in part because she fell between the dominant interpretations of feminism and anti-racism ... the raced and gendered dimensions of her position could not be told ... [a] consequence of anti-racism’s essentializing Blackness and feminism’s essentializing womanhood ... [such that] the narratives of gender are based on the experience of white, middle-class women, and the narratives of race are based on the experience of Black men. (Crenshaw, 1991, p.107)

Attending to those at such intersections is vital work. It is not merely enough to attend to each of these things individually, but attention must be paid to the lived experiences and social settings of those at the intersections.

In the introduction to their 2012 book, *Museums, Equality and Social Justice*, Nightingale and Sandell direct attention to the palpable movement within museums to embracing narratives of “demographic, social and cultural diversity” (Nightingale & Sandell, 2012, p.1), to structuring aims, purposes, and values around “moral standpoints” (p.1), leading up to their moment of writing. They attend to concerns raised by, for example, Janes (2009) that there is also the possibility that the movements toward equity and social justice “is slowing down or even ... reversing” (Nightingale & Sandell, 2012, p.2). As a foundational text on these movements, it is interesting to explore how Nightingale and Sandell distinguish ‘equity’, ‘diversity’, and ‘social justice’. Presented separately, ‘equity’ is summarized by drawing on legal definitions of “elimination of discrimination on the grounds of group membership” (Nightingale & Sandell, 2012, p.3), whereas ‘diversity’ is
understood as “measures intended to celebrate, promote respect for, and enhance understanding of difference ... [and] to harness the benefits of diverse staff” (Nightingale & Sandell, 2012, p.3). Social justice, then, is:

ways in which museums, galleries and heritage organisations might acknowledge and act upon inequalities within and outside of the cultural domain ... their capacity to both shape as well as reflect social and political relations and positively impact lived experiences of those who experience discrimination and prejudice. (Nightingale & Sandell, 2012, p.3)

Thus, Nightingale and Sandell suggest that museums may enact both distributive (“shape and reflect”) and redistributive (“act upon inequalities”) social justice within their actions, despite acknowledging the museum’s role in being a force used historically to marginalize, oppress, and exclude groups and individuals. These abilities of museums are particularly evidenced by the impact of reshaping the narrative in museums (RCMG/Wellcome, 2020; Sandell, 2007).

The examples of activism projects in science and technology museums are few, and books such as Museum Activism (Janes & Sandell, 2019), and Museums, Equity and Social Justice (Nightingale & Sandell, 2013) lean into discussing socio-historical and arts museums, with very little to say about how activism and social justice work can or has taken place within science and technology spaces. As such, my thesis looks at how such work might take place in relation to science and technology museums.

2.2.2.2 Exploring activism and social justice in museums

To help lay out ways that social justice work could take place within the museum, I will separate some exemplar projects out by who is actioning the social justice action, to explore work that is (i) museum-led; (ii) co-creation between museum and publics; and
(iii) public-led. Whilst I have done this for ease of structure in my literature review, I wish to highlight the importance of recognising that any good social justice project in a museum cannot be limited, and perhaps should span multiple registers in order to direct sustained change.

2.2.2.2.1 Museum-led interventions

Museum-led social justice can take a number of different forms. In this context, I am understanding ‘museum’ not as an abstracted institution, but in the actions, words, and behaviours of people working for the institution. It is the senior management, curators, administrators, exhibition development teams, publicity, front of house, and facilities staff who produce and action these social justice projects. These are the people who are making the decisions about social justice issues like equitable wages for employees, who is employed, how an exhibition is structured, whose knowledge is valued in the construction of galleries, or how the museum acknowledges or challenges colonial, imperial, racist, homophobic, misogynistic, or ableist displays or acts. Much like the field of social justice itself, it is key for theorists and museum professionals alike to recognise that it is they (and not some arbitrary idea of ‘the institution’) that affects change in the surrounds.

This museum-led work can range from systematic, museum-wide change down to small-scale changes that individuals make within their working practice. In 2018, Nina Simon’s restructure of the Santa Cruz Museum of Art & History through the OFBYFOR framework (Simon, 2016) gained popularity as a selection of international museums followed suit to reorient their museums to be spaces that work with local communities to contain artefacts ‘of’ the community in their collection, designed ‘by’ the community, and to be developed ‘for’ the community the museum works with (OF/BY/FOR ALL, 2020). Similar changes were instigated at the Middlesbrough Institute of Modern Art (visitmima.com), publicised as the ‘Useful Museum/Museum 3.0’ project, based on
Wright’s *Towards a Lexicon of Usership* (2013). The museum-wide shift aims to demonstrate how the museum can be socially and politically relevant to the local community (Villegas, 2016). Likewise, a reimaging of the purpose of the plantation tour in the South of the United States of America led to sites including the Whitney Plantation (Louisiana), the Owens-Thomas House and Slave Quarters (Georgia), McLeod Plantation (South Carolina), and Monticello Plantation (Virginia). Instead of focusing on white slave owners, the stories of Black, enslaved people are centred at these locations – their names and voices heard through utilising historic documents, buildings, experiences, and daily lives as the subject of the tour (Mzezewa, 2019). The relationship of the enslaved to the slave owners is not hidden.

Instead, the brutal realities of the production of wealth for the few white slave owners on these sites is addressed. Changes at, for example, the Whitney Plantation are not only found in the structure of the tour, but also the in materials that are sold at the shop, the people employed at the site, and types of public functions that the site hosts (Whitney Plantation, 2020). By contrast to the books centred on the lives of African American and Indigenous slaves sold at the Whitney Plantation, other proximate plantations sold trinkets such as cotton angel Christmas tree decorations and white dolls (see Figures 2a and 2b).
Figure 2a and 2b: Books on sale at the Whitney Plantation (left, Summer 2019) and cotton angel Christmas tree decorations at the Laura Plantation (right, Summer 2019). (Image credits: E. S. Armstrong).
Some museum-public social justice projects are short-term, or linked explicitly only to one worker within the museum, rather than embedding change across the institution, for example making an individual responsible for ‘decolonial’ work, or ‘queering’ the collection. For instance, museum interventions such as *Decolonise Science Narratives* (MacNicol & Saggar, 2019) rest on actions that are localised to individual positions in the institution rather than systematically incorporated across all (in this case) curatorial and research roles. Inviting artists in to make interventions in the gallery such as Mining the Museum (Wilson, 1992) does similar work – localising (uncomfortable) critique of the institution onto a single individual. Reflecting on my own experience on a museum learning team, it was interesting that challenges to museum authorities on gendered and heteronormative narratives were seen as being ‘my thing’ and thus other members of the team brought these issues to me. These were expected to be things that I should/could raise, address, or otherwise resolve, rather than being something that all members of our learning team needed to tackle.

Social justice projects within this understanding of ‘museums’ also span institutions. The role of cross-institutional communities in developing (UK) networks such as *Museum Detox* (2020), *Museums as Muck* (2020), and *Fair Museum Jobs* (2020) allows colleagues to push for sector-wide changes in, for example, language used, payments, and processes. Thinking about systematic changes for distributive social justice around gender and sexuality in museums might result in equal parental leave, medical leave for transitioning employees, and clear, robust, and enforced anti-harassment policies. As this thesis is not tackling these issues from inside the institution, I will not return to these concerns, but these are important issues that collectively the sector must address.

### Museum-public projects

There exists a large portion of scholarly literature that is about grassroots change in the methods and practices of museum culture through (often) single project museum-public...
collaboration. Here ‘public’ is understood as anyone not formally employed by a museum or gallery, to take as wide a scope as possible. Most visible in Museum Activism (2019) are the multifarious ways that publics and museums can interact – through volunteer efforts (Curran, 2019b), Twitter activism (Carvill Schellenbacher, 2019), and decolonial approaches to co-curation with members of the public (Wajid & Minott, 2019) – as well as urging activist stances of the individual within the museum even if ‘the institution’ is not committed itself as a collective to the change. Many such projects operate explicitly along an axis of social justice. Bringing forward the earlier discussion about the importance of addressing intersectional identities, it is crucial that museum-public engagements are critically conscious of how they choose to do this social justice work, as well as the plurality of the communities they seek to work with.

This work can be done with a number of different ‘publics’, and there are a multitude of collaborative pairings including work with scholars (Devoy, 2010), community groups (National Martime Museum, n.d.), educational groups (Uncomfortable Truths, 2019), professional experts (Aidoo-Davies, 2020), and activist groups (RCMG/Wellcome Collection, 2020). It is vital to be aware of power imbalances in practices that involve publics. For instance, the Victoria and Albert Museum’s redisplay of the Maqdala collection invited leading figures of diasporic Ethiopian communities to comment and engage with the gold and silver artefacts on display (V&A Blog, 2018). However, demonstrating some of the elements of this power imbalance, religious community leaders were not invited to comment on the spiritual artefacts in the collection; instead, their voices were attributed to other non-religious artefacts, whereas ‘expert’ curatorial voices for religious objects were centred and given prominence. What appears to be reparative social justice work in the museum can in fact be seen as a way of reasserting the museum as the correct place for locating these artefacts through privileging the knowledge of museum experts.
Reparative justice projects on queerness in museums abound, including, for example, LGBTQ tours at the Victoria and Albert Museum (Vo, 2015), inclusion of queer lives by students in The Summer History Immersion Programme (Parsons & Van Cleve, 2015), archiving of two spirit stories in the University of Winnipeg in collaboration with the Manitoba 2SLGBTQ+ community (McLeod & Lougheed, 2019), or using the Bode Museum collections to co-create LGBTQ+ and sex education classes (lab.bode, n.d).

These projects are characterised by collaborative work between specific community groups and one or two professionals working in the institution. Critiques around anxieties of sexuality and race or disability sometimes limit the understanding of the intersectional identities of queer communities of colour (Somerville, 2000) and/or disability (McRuer, 2006).

2.2.2.2.3 Public-led interventions

Social justice work is both about understanding the just reaction to take and understanding the harm being perpetrated. Public-led projects can do both of these, but are often particularly good at highlighting the harm being perpetrated in the museum or cultural space. Activist projects such as Untold Histories (Mishra et al., ’2019), Decolonize this Place (DTP, n.d.), The White Pube (de la Puente & Muhammad, n.d.), The Uncomfortable Art Tours (Procter, n.d.), Museums are not Neutral (Autry & Murawski, 2019), or Liberate Tate (n.d.) have challenged narratives around racialization, colonialism, and climate emergencies. These public-led interventions often sit outside the ‘narrower’ narratives of the museum, explicitly rejecting the status quo in favor of presenting a different vision for the heritage site. Less divisive public-led interventions are also possible; for example, groups such as Cemetery Club (Goodman, n.d.) challenge the narratives around death and dying in public spaces, or interventions around access for those with disabilities (e.g. Watlington, 2020) but all are motivated by the urgency for change in public institutions with the recognition that these spaces shape the ways that visitors conceptualize their social worlds and their positions in the world.
These examples give a sense of the scope of what is possible and the impact of social justice from outside the museum explicitly targeting the construction, display, development and narratives around museums. In this section, it has been harder to articulate concretely the impact of these ‘others’ in challenging the stories – sometimes institutions do not want to recognise when they have been influenced into changing a position that they have previously held; sometimes it may not be the institution where the harm is situated that makes the change, but another institution responding to the calls to action in the interventions.

2.2.2.3 **Summary**

In this section on describing social justice in museums, I have detailed what social justice is, the fundamental importance of working on intersectional social justice, and how it can be understood in the context of education and more specifically in the context of museums. I then moved to giving examples of distributive and reparative social justice projects that are or have been taking place in museums internationally, highlighting the importance of initiatives that are led from inside museums, by members of the public, and projects that are worked on collaboratively between the two. In these examples, we can see reflected Nightingale and Sandell’s assertion that:


[m]useums, heritage and culture not only reflect but also shape normative conceptions of fairness and power relations between groups; [but also] impact individuals’ lived experiences. (Sandell & Nightingale, 2012, p.2)

Constructing galleries co-constructs a normative understanding of that subject matter. It is vital therefore that not only the content, but also the audience and the intention of the message is interrogated in the museum context.
2.3 Learning in public spaces

The social world in which we construct our lives iteratively shapes the possibilities of being through what is shown and displayed. In this section of my literature review I shall introduce theories to conceptualise the social world as a construct, and then theorise about how learning interacts with this idea.

2.3.1 Narratives and imaginaries in the museum

Lyotard’s articulation of the *grand récit* (which I will translate as grand narrative, but has elsewhere been termed metanarrative or master narrative) can be understood as a reflection on Hegel’s positioning of a reflective Universal History. Hegel theorised three methods for treating history including Reflective History, in which the aim of the investigator to gain a view of the entire history of a people or a country, or of the world ... [and must] indeed forego the attempt to give individual representations of the past as it actually existed. (Hegel, 1837, §6-7)

Lyotard (1984) theorised that modernity could be characterised by two grand narratives: the Enlightenment (the narrative of infinite progress and liberty) and Science (the triumph of pure knowledge). Furthermore, Lyotard argues, postmodernism is characterised by an incredulity towards grand narratives, that is, a rejection of totalising stories that legitimise knowledges and cultural practices, and, as a consequence, power (Lyotard, 1984).

Grand narratives can be narratives about the past that are canonized by party and state, or, in the case of my thesis, museums. The manifestation of grand narrative can take many modes, including defining the standard unfolding of political events related in the canon (a set of accepted ‘parts’ of culture) (Erler & Kowaleski, 2004), most frequently
characterised as a patriarchal narrative that privileges the actions, opinions, and texts of men either on the macroscale (for example, at the scale of institutional relations or development) or on the microscale (including readings of individual items or texts), and has masculine figures occupy the agential or ‘subject position’ in the narrative constructed.

While modernity may have been characterised by a grand narrative of Science as the triumph of pure knowledge, Lyotard argues that the characteristic of postmodernity is that Science is now the dominant knowledge, and therefore no longer validated by narratives of knowledge (Lyotard, 1984). Consequently, in postmodernity, Science is only regulated by a recourse to itself (scientific knowledge), and to performativity of the ‘technological criterion’, suggesting that output of knowledge and information is the greatest value that can be created.

Despite Lyotard arguing that grand narratives are a function of modernity that are no longer in operation, many theorists suggest that they are still in force. For instance, petit récit, or little narratives, are used to make sense at the level on the individual. These little narratives are in conversation with grand narratives; both resort to and corroborate, but also resist and subvert, the dominant narratives themselves (Bamberg & Andrews, 2004). Furthermore, feminist theorists argue that other grand narratives around the Other (e.g. de Beauvoir, 1949), or white patriarchy (e.g. hooks, 2004) still pervade the ‘postmodern’ period, still structuring an appeal to forms of knowledge and/or power. Indeed, co-constructed knowledge and power sit not only at the centre of a white patriarchal narrative, but also heterosexuality (Foucault, 1972). This suggests that grand narratives exist in the postmodern period, even if that grand narrative is to have no cohesive grand narrative.

In science and technology, grand narratives have been used to justify making scientific or technological investments by appealing to narratives that equate science with progress.
These narratives are often extrapolated from past events and frequently provide explanatory or justificatory modes of engagement. Thus, they are developed to help rationalise how the current state was reached (Silverstone, 1992).

By contrast, sociological theorists frequently make appeals to the imaginary as a set of values, institutions, laws, or symbols that could be understood to codify a social group. Originating in Lacanian psychoanalysis, the Imaginary is an understanding of who and what one images others to be; the imaginary is fictional, simulated, and virtual (Johnston, 2018). However, this does not mean imaginaries are illusionary, inconsequential, or unimportant; in fact, far from this, they have definite effects on actual, lived human realities.

Lacan later emphasised the importance of the Imaginary on the Symbolic, the customs, institutions, laws, norms, practices, rituals, rules, and traditions that provide the structures and syntax for the world (Lacan, in Johnston, 2018). This implies that the phenomena experienced in the sensory (e.g. images, touch, conscious emotions, imagining the thoughts and feelings of others) are informed and determined by the Symbolic structures that the experiences take place within.

Sociological imaginaries, inflected by Castoriadis’ (1975) theorising on society, have been expressed as developing ideas about expansive imaginaries, for example, the Cultural Imaginary (Hall, 1996a), Technoscientific Imaginaries (Marcus, 1995), or Sociotechnical Imaginaries (Jasanoff & Kim, 2009), or specific imaginaries such as Imaginaries of Caribbean identity (Praeger, 2003) or the Internet (Mosco, 2005). Imaginaries are multiple and various, and are operationalised in different ways in different pieces of research – variously as the object of analysis, an analytic device or as the end point of identification through other analysis (Nerlich & Morris, 2015).
In relation to science and technology, anthropologist Marcus (1995), in theorising about the role of scientists, scientific practice, and moral and professional issues, specifically articulated the ways that understandings of the world were practised and shaped behaviour. Rather than understanding the practice of science in isolation, Jasanoff and Kim’s theorisation of sociotechnical imaginaries understands an interplay between national identity and national level science and technology projects, such that the imaginary has

the power to influence technological design, channel public expenditure, and justify the inclusion or exclusion of citizens with respect to the benefits of technological progress. (Jasanoff & Kim, 2009, p.120)

The focus of their work is the material consequences of such imaginaries, by being focused on the future, how the imaginaries are instrumentalised, or attained, and how they moderate social actions in the present. Indeed, imaginaries structure and co-constitute social practices; for example, Levy and Spicer (2013) demonstrate that there are multiple different Climate imaginaries, and these imaginaries provide coherence and orientation to those who operate within a particular imaginary in developing actions around the climate emergency.

While the two concepts of the grand narrative and imaginary are similar, and describe overlapping phenomena, they cannot be used interchangeably. However, both are valuable and at play in the science and technology museum. The museum gallery provides space for narrative about what has led to the point at which we are now (through the uses of grand and little narratives) that constructs an argument as to how we arrived at (and what is) the status quo for science and technology. Similarly, imaginaries, as a more future-oriented theorisation of the ways things are and will be, are present in these galleries too. Imaginaries create the impetus for state actions, and the necessary political resolve to attain them. Museums, often as state-funded institutions, are sites that both
historicise a national narrative, and develop future-oriented motivations, often simultaneously and in close physical proximity. While Jasanoff and Kim (2015) specifically cite the museum as a location where the sociotechnical imaginary is stabilised, such that it is able to motivate political action, I argue that the museum is also the site of creating narratives and imaginaries by staff working at these sites informed by political action.

### 2.3.2 Critical pedagogy

Kelly (2009) suggests that the term ‘curriculum’ can take many different meanings, but can be broadly understood to be the “total programme of an … institution” (Kelly, 2009, p.9), encompassing “all learning planned and guided” by the institution, and the “overall rationale” for any programme (Kerr, 1968, p.16). While within education, ‘curriculum’ is often considered to be “what teaching and instruction is to be offered and sometimes also what its purposes, its objectives [are]” (Kelly, 2009, p.7), the term describes not just the material that is officially on the syllabus. A ‘hidden’ curriculum, that which is learnt by “the way in which the work of the [institution] is planned and organized, and through the materials provided” (Kelly, 2009, p.10) is also pertinent to learners. Though it may not be being made explicit, it carries significant weight in the understanding of the institution and the choices that are being made within it. There are also possible distinctions between what is planned for learners in the curriculum, and what is received by the learners in the teaching (Kelly, 2009), what is considered to be ‘official’ learning and what is ‘unofficial’.

Conversely, pedagogy can be conceived of as the positionality, or mode and motivation of the teaching. Pedagogy considers how the teaching is in conversation with, and informed by, societal beliefs. Arguably, pedagogy cannot exist outside larger ideals or beliefs, as these aims and objectives give purpose to the education and shape what is taught, to whom, and how. For instance, Freire’s convictions of justice, power, and critical
consciousness shaped the content and the mode of education constructed with Brazilian villagers (Freire, 1995). Ideals and beliefs are demonstrated to inform approaches to education; feminist pedagogy, for example, understands that human experiences are shaped by and shape expectations of gender, gendered roles, and their limitations, and challenges these boundaries (for example, hooks, 2004). Culturally Relevant Pedagogy practice works to frame the experiences of educations as relevant and affirming to students who do not fit a white, Eurocentric profile of a learner (for example, Ladson-Billings, 2014). Thus, while I will understand the curriculum as the learning programme of the institution – in this case the museum – the pedagogy is the motivation, informed by ideals and beliefs in society, that shapes what content is delivered and how within that space.

Critical pedagogy can be understood as a framework that allows critique of how and what knowledge is transmitted and learned by individuals. Taking a critical approach within the classroom could be understood as facilitating students to see society as problematic but, rather than closing discussion down at this point, to open this to students to change the perceived oppression by society. Giroux asserted that:

> pedagogy cannot be reduced only to learning critical skills or theoretical traditions but must also be infused with the possibility of using interpretation as a mode of intervention, as a potentially energizing process that gets students to both think and act differently. (Giroux, 2011, p.14)

Whilst critical pedagogy grew out of critical theory more broadly, which itself is attentive to the construction, (ab)uses, and depictions in the social world around us, I will be using the approaches of critical pedagogy to be specifically attentive to intersectional queer feminist concerns. I will explore the grounding of critical pedagogy, its previous applications in education and museums, and will justify why this approach is particularly suitable for my thesis by understanding the articulations and actions of ‘reader-response’.
Using a critical pedagogy approach has not only developed my work as a researcher on this thesis, but has also impacted my other educative work – see my Impact Statement for more detail about these elements of my praxis.

Giroux (2005) initially used the concept of ‘public pedagogy’ to understand the marketisation of education, and a neo-liberal turn within the educational framework. While critical pedagogy has always been “fundamentally concerned with centrality of politics and power in our understanding” (McLaren, 1994, p.167) of education and learning, bringing this into conversation with the idea of public pedagogy allows us to understand the power and politics in learning beyond formal education, and the tensions about what is considered within the scope of formal education. Apple argues it is always an economic, political, and ideological process to move particular types of knowledge from being ‘official’ as opposed to ‘popular’ (Apple, 2003), and thus to understand both what is seen as ‘official’ knowledge (and by extension, the method of its teaching) and how something becomes ‘official’ knowledge are crucial to theorists of education. Apple’s assertions echo ideas of Bourdieu’s designated, valued types of cultural capital (Bourdieu, 1986), and can be extended by introducing Yosso’s reflection that the ‘unofficial’, or in Apple’s critical pedagogy frame ‘popular’, modes of knowledge are valuable and important in and of themselves (Yosso, 2005). Ultimately, we might see critical pedagogy as a framework allowing a challenge to museums as holders of neutral knowledge, instead understanding them as inflected by political actions of sanctioning official narratives.

McLaren (1994) understands critical pedagogy as fundamentally concerned with the centrality of politics and power in our understanding of education and learning. In terms of application to museums, theorists have particularly used critical pedagogy frameworks as a challenge to the perception of the ‘cultural arbitrariness’ of museums – to refrain from seeing them as repositories of neutral knowledge, but rather as Eurocentric, class biased, racialised spaces (Lindauer, 2006; Marstine, 2006; Mayo, 2013; Tatum, 1997).
Dardier (2011) addresses how the collecting of materials to the status of ‘culture’ within a museum is an act of power that further marginalises communities already racialised and disenfranchised by cultural institutions such as museums, such that these institutions act as a supplementary curriculum that provides legitimacy to some forms of knowledge and not others (Borg & Mayo, 2000). More recently, El-Amin and Cohen (2018) have demonstrated the use of critical pedagogy approaches in museum galleries. Their paper operationalises the critical pedagogy framework to understand the roles of focused highlighting of objects and positioning in the gallery, and of critical literacy for students in the museum context. Similar ideas about criticality in the museum can be seen expressed in the Critical Dreaming practice on of the Museum Queeries group (Butler & Lehrer, 2016).

Likewise, construction, development, and the maintenance of archives is a political, educative act. The privilege and ‘right’ to protect and maintain a cohesive, detailed archive of particular materials, contexts, and narratives in a particular way (or, indeed, to end the collection (Jardine et al., 2019)) has been strongly contested through (amongst others) decolonial lenses (e.g. Arondekar, 2009; Stoler, 2009). Indeed, the archive only appears rich and dense when looking for hegemonic narratives; this fetishization of the richness of documentation of the past simply cannot happen for many communities (Muñoz, 2009; Steedman, 2001). Instead, queer theorists have argued that rather than trying to fit into the archive, reshaping it (Singh, 2018; Trinh, 2010) or challenging the elements of what make an archive (Schneider, 2011; Taylor, 2003) could change the potential of the archive. These same challenges around ‘lost’ or ephemeral histories in technoscientific collections of artefacts and documents open space for new possibilities for objects that already exist in the collection and for those that are ongoingly being accessioned into it.

Thus, a critical pedagogy approach will be introduced in my thesis to understand the types and roles of imaginaries and narratives constructed within the science museum galleries.
Utilising a critical approach alongside an activist lens will help understand the impacts of pedagogical approaches in the museum.

2.3.3 Science communication and the museum; learning in science museums

Often, rather than being situated within educational literature, learning within science communication is framed within the discourses of models of communication in the field of science communication (Davies & Horst, 2016). Science communication (broadly constructed here to include the fields of Public Understanding of Science, Public Engagement in Science and Technology, and Science Communication – a discussion of the distinctions can be found in Bowater and Yeoman (2012)) in the early twenty-first century is frequently framed within the historiography of a move from the deficit model to the dialogue models of communication. Deficit models, where one-way, top-down communication of scientific information frames the movement of knowledge from experts to non-experts (or publics) (Wynne, 1991; Ziman, 1991), are posited as inferior to dialogical models, that involve conversations between scientists and publics (Whitmarsh et al., 2005; Russell, 2010). Characterised by Trench as a grand narrative with “compelling force” (Trench, 2008, p.120), the idea of a move within science communication from deficit to dialogue has been picked up and instrumentalised in many geographies and for many uses, creating an apparently universal consensus about how science communication should or could be theorised (Rauchfleish & Schäfer, 2018). More recent work rebukes this universalisation of the disciplinary history (e.g. Dayé, 2018), and an idea of unilateral improvement over time, but works instead to challenge a Western, Enlightenment-centric perspective (Orthia, 2020), one that focuses on science at the expense of culture (Gondwe & Longnecker, 2015), or a teleology that excludes (and precludes inclusion on the basis of categories) Indigenous Knowledges (Ball, 2015).

Rejection of this model of transition from deficit to dialogue also takes place on the basis that events touted as ‘dialogue’ transpire to be a mix between deficit and dialogue
(Davies, 2009), and that even if done with good intent and delivery, there is evidence that they do not make material change in scientific practice or policy (Chilvers, 2006; Whitmarsh et al., 2005). Furthermore, these forms of two-way engagement often recruit those already interested in the science (Nisbet & Scheufele, 2009), are difficult to scale well to truly form dialogical relationships with large audiences (Bowater & Yeoman, 2012), and are often not focused on shaping research agendas, but rather work on engaging publics with outcomes (Turney, 2011).

Included within the field of science communication, science and technology museums are often framed as archetypal examples of the deficit model; with science centres occupying a more dialogical (but still not ‘truly two-way’) form of engagement (Gouveia & Kurtenback, 2009; Schiele, 2008). Some theorists suggest that there is a dialogical relationship between publics and museums (Rodari & Merzagora, 2007), especially when considered at the level of museum educators and publics (Tal & Steiner, 2006). Science and technology museums do work defining what ‘science’ is for people the museum constructs as ‘the public’ or ‘publics’ (see Section 2.2.1), and define for themselves what these various terms mean in the construction of their galleries (Macdonald, 1996).

Debates are ongoing about, for instance, whether it is possible to display unfinished science (Hine & Medvecky, 2015), or controversies (Yaneva et al., 2009), or if one can develop emotional engagement (Davies & Horst, 2016). Do science and technology museums display a history of science (Durant, 1992), or contemporary research (Davis, 2004; Laurent, 2012), or are they focused on more social features of science, for example engaging visitors in science policy in the museum (Bell, 2008), of science fiction and comics (Tatalovic, 2009)? Indeed, are science museums even truly part of the science communication field? Macdonald argues that there are distinct differences between science museums and other forms of sciences communication, including “the relative permanence of displays in science museums ... their immediacy and the presence of “the real thing”” (Macdonald, 1996, p.152) that might preclude them from being properly treated analogously with other science communication enterprises.
2.4 Gender, sex, and sexuality

Queer theory and feminism have both challenged the constructions of gender and sex. Challenges are wide ranging: from the notions of being able to categorise humans into binary genders (Kesser & McKenna, 1978), to the arbitrariness of such taxonomies (Borges, 1942), the role of different genders (de Beauvoir, 1949; hooks, 2004), or how these constructions demonstrate systems of power (Foucault, 1978). Theorists have charted the imaginaries that inform these constructs (Irigaray, 1985), how narratives can be taught (Catherwood, 2017), and how social shifts (Laqueur, 1990) and educational motifs (Rousseau, 1763; Wollstonecraft, 1995) that shape ‘scientific’ constructions of gender and/or sex are constructed, as well how both the social and physical manifestations of femininity can be understood as socially constructed (Bordo, 1989; Gilbert & Clavert, 2003; Howes, 2002; Thornes, 1993). The very separation of gender and sex comes from the effort of feminist theorists (e.g. Rennie, 1998), and moving beyond their binarization, and the necessity to tie particular gendered and sexual identities to particularly sexed bodies (e.g. Letts, 2001; Scantlebury & Baker, 2007) has been an important step taken by queer theorists. There are many more extensive pieces that discuss these practices and the expansive nature of these works of theoretical critique (e.g. Gilbert, 2001), but they will not be explored here further. Instead, I want to draw particular attention to the way such arguments about gender and sex are theorised and used in science (and) educational literature, and make clear some challenges to using feminist science education work in the foundation of this queer feminist research.

While many educational literatures across formal and informal science learning make a distinction between sex and gender, the studies, analyses, and discussions that follow often belie taking this feminist and queer critique to the heart of the research programme. Mixed use of terms ‘girls’ and ‘females’ (e.g. Dancstep & Sindorf, 2018a, 2018b), or an expression of wanting to separate gender and sex ideas but then writing about them as
overlapping make for mired research starting points. For instance, while Brotman and Moore, in their systematic review of literature on girls and science education, note that the review is predicated on an “historically inequitable situation for females in relation to science and science education, a situation based on sex difference” (Brotman & Moore, 2007, p.975), they describe that it is “girls, who as a sex have been marginalised from science” (Brotman & Moore, 2007 p.975). An unsatisfactory resolution of this problem, in my opinion, sees the authors acknowledge that “sex inequities are largely rooted in socially and culturally constructed ideas about gender” (Brotman & Moore, 2007, p.975, emphasis in the original) but to continue to use the term ‘girls’ to refer to those sexed as female.

Rennie (1998) makes the case that this overlap between sex and gender is rife in the literature of science education, and ten years later Glasser and Smith argued, using examples from the literature, that this was still the case and as a result “the pattern of unclear, conflated and even synonymous use of the terms has slowed progress in understanding how gender influences students’ educational experiences” (Glasser & Smith, 2008, p.343). Even in their construction of a handbook in 2016, Baily and Graves note that any work on gender and education includes projects such as those analyzing the social implications of biological sex differences between males and females, those focusing on women, and those employing contemporary theories of gender as a fluid, heteroglossic, and always unstable entity. For some, such terms are inherently unstable or hold multiple meanings within the same project. (Baily & Graves, 2016, p.683)

This conflation and synonymous use of terms to do with gender and sex is particularly problematic at the moment of writing this thesis (2020), with the rise of particular branches of feminism that exclude trans* identities at their core – including (but not limited to) what is termed ‘trans exclusionary radical feminism’ (TERF). Theorising
being a ‘woman’ (or, in the case of the education theories mentioned here, a ‘girl’) through the bounding of identities, spaces and bodily autonomy gives rise to key sites of tension for TERFs, but also key sites of social justice work to be done to bring trans* theory together with other feminist projects (Hines, 2017). Whilst earlier conflation of gender and sex might have not have the same undertones, my rejection of a ‘feminist’ discourse that fails to decenters biological essentialism, as well as failing to have an emphasis on giving centre stage to non-binary gender identities, intersex identities, and trans* identities makes use of educational literature and museum literature that does rest on problematic binarised understandings. Indeed, as I will go on to discuss in my Methods and again when using the interpretive framework for interactives, the conflation of sex and gender means I am culpable of the same pattern Rennie (1998) noted. I have explained how I have challenged the framework described as ‘female’ oriented but used to describe gendered performances of ‘girl’ and femininity, but cannot escape the fact that the framework itself is built on this elision and the same reading of gender as being synonymous or even conflated with sex.

However, this impasse should not leave us defeatist. Elsewhere, urgent calls to action are centred on the importance of pluralizing education for everyone, not just thinking within a gender/sex problematic. For instance, Sapon-Shevin considers how important narratives around gender and sexuality are in education in constructing the world for children – and that thus these “lessons are important for everyone, not simply those with a particular gender/sexual identity” (Sapon-Shevin, 2009, p.280). Indeed, the two themselves can never be fully disentangled, because “a performance of heterosexuality must always be in some sense a performance of gender, because heterosexuality requires gender differentiation” (Cameron & Kulick, 2003, p.72). Rather than working within a system of education (both formal and informal) that is “ultimately focused on assimilation and reform” of those with non-normative identity, how could education be shaped instead towards “authentic cultural pluralism and radical social change” (Rofes,
To enact these kinds of radical (re)distributive social justices, Sapon-Shevin argues we must attend to intersectional and multiple identities that individuals hold:

even school solutions designed to help marginalized youth often fail to take into account multiple identities; safe havens for some are still alien spaces for others. (Sapon-Shevin, 2009, p.281)

It is thus imperative to investigate critically literature around gender and sex within formal and informal learning, to interrogate what can usefully be taken forward and utilised to advance research done from a queer perspective. Going on from here in the thesis I have demonstrated where I take a queer challenge to materials and how this has helped shape the materials. I have also indicated where such theories have guided me to open space in the method, analysis, or discussion, to exemplify a queer feminist research project about science education in museums settings.

2.5 Thesis research questions

In this literature review I have developed a number of ways of theorising about museum display – thinking critically about what is presented, how this constructs narratives and teachings in those spaces, and use these as a way of thinking about whether museums confirm or challenge these stories. My literature review has been developed alongside the formulation of my research questions. Iteratively, I have read, formulated questions and developed, refined, and specified the research questions that I will explore in the rest of the thesis.

I begin from the premise that individuals learn in museum gallery spaces, and they are taught a constructed curriculum through the pedagogy of the museum gallery. These pedagogies are taken in in the form of narratives and imaginaries, that stabilise, develop or
construct new ideas about what science is and how it is constructed. Through the literature review, I have developed notions about what a ‘narrative’ or an ‘imaginary’ is, the ways in which these might be challenged or developed within the museum, as well as the relationship between narratives and imaginaries in museums and public concepts of a field. The understanding that there is an accepted curriculum, constructed into narratives, guided by which learning takes place in public spaces, was introduced through readings of theorists such as Giroux and Freire, and was situated within the museum in Section 2.3.

As developed in my Introduction and Section 2.2, I am particularly interested in how social justice movements intersect with taking queer feminist approaches to understanding narratives and imaginaries in museums. While physical science museums (as opposed to, for example, natural history or medicine museums) may have been seen as hegemonic spaces of articulating (masculine-coded) technology and science narratives, in the recent past there has been a move to considering women in these museum spaces. Alongside movements in arts and socio-historical spaces to reclaim women into the canon – looking for the ‘female Leonardo Da Vinci’ for instance – female scientists of the past have been ‘reclaimed’ into the canon of scientists. Women such as Marie Curie, Dorothy Hodgkin, Rosalind Franklin, and Ada Lovelace occupy these positions, asserting that women were important in histories of radioactive studies, crystallography of proteins, and computing, thus, also to these histories of science.

However, much as Nochlin questions how the definition of being a ‘great artist’ is predicated on an “intellectual and ideological basis of the various intellectual or scholarly disciplines” (Nochlin, 1971, p.1) – even buying into trying to assert that there were ‘great women’ in the past is only to reinscribe the problems of having a definition that is steeped in masculine traits, and “naive, distorted, uncritical assumptions about the making of art in general” (Nochlin, 1971, p.7). Mythologised geniuses populate the history of the canonical artists and scientists, abstracted from their situations and circumstances, allowing obfuscation about why there were fewer, for example, white women or people
of Colour depicted in the same manner. Thus, as covered earlier in this literature review, I take an expanded scope to address what ‘gender’ might look like in narrative construction. It is not just attention to women. Informed by my queer feminist position I expect to look at gender as a spectrum (though even ‘spectrum’ could be read as a unidimensional approach), considering trans*, non-binary, gender-queer, and gender-nonconforming individuals as well as gendered categories of ‘men’ and ‘women’. Moreover, queer is attentive to understanding sex and gender as constructed categories (Butler, 1990); thus, I shall also pay explicit attention to the ways that sex and gender might be collapsed upon one another in the galleries I shall look at. In the case examples I have given earlier in the literature review, it is important to recognise that it also not just about the gender of individuals, but also gendered norms that may be co-constructed within the narratives in the museums. What constructions are being made around feminine or masculine traits? How are they valued relative to each other in the narrative constructions? Which bodies, if any, are they associated with? Are some traits universalised as being ‘scientific’ in the space and are these themselves gendered too? Ideas about gendered traits extend into racialised, classed dimensions, and have implications around disability, geography, and imperialism too. As I will be taking an intersectional approach, these too will be cause for attention in the research I conduct in this thesis.

Moreover, patriarchal ideas about gender are tied explicitly with ideas about acceptable and appropriate sexual desires and behaviours in particular bodies too, such that “a performance of heterosexuality must always be in some sense a performance of gender, because heterosexuality requires gender differentiation” (Cameron & Kulick, 2003, p. 72).

My queer feminist position also seeks to asks questions about constructions about sexuality in physical sciences. Some STEMM professionals have questioned if STEMM fields should be a context within which to theorise or think critically about constructions
of sexuality. This is also true of gender and race but – perhaps – these conversations are becoming more normalised as they are less ‘hidden’ in the public domain.

However, my work in this thesis seeks not only to challenge the idea that gender and sexuality are not something that should be discussed in STEMM fields, but also the idea that the science museum is a handmaiden to STEMM professionals and that it could not challenge, develop or create new narratives and expectations around what is important in STEMM. For instance, heteronormative relationships play an important role in both the successes of women STEMM professionals and their acceptability as STEMM professionals. As a case study, Marie Skłodowska Curie’s relationship with Pierre Curie brought her (amongst many other things) laboratory space, integral to conducting research. Unmarried or not married to a white, wealthy, and well-connected man, Marie Skłodowska Curie might (would) not have had this access and thus not the research with which to be elevated to a ‘great scientist’ (as problematic as this term is, discussed above). Women in heterosexual partnerships were often imperative to the successes of their partners’ science, even if they weren’t themselves considered ‘scientists’ in a canonical sense. For instance, Pang describes how Elizabeth Campbell, wife of Lick Observatory director William Wallace Campbell, played a key role in the expeditions that the Lick Observatory mounted, not only planning them but going into the field with Wallace to attend to him, and managing the expedition finances, servants, and supplies – roles she would not have held without the privilege of an undergraduate education that introduced her to Wallace and led to their marriage (Pang, 1996). As illustrated in Pang’s history, critical of the premise that sexuality is not something to concern oneself with in science, I intend not only to be attentive to queer relationships in these spaces, but also think about how heteronormative relationships are discussed and presented too.

And so, the first research question that my thesis attends to is:
Question 1: What gender and sexuality narratives exist within London space science galleries?

In order to be attentive to different ways that these narratives could play out, and where they might be situated, I have three subsidiary questions:

(a) How do gender and sexuality appear in narrative constructions about science?
(b) How do gender and sexuality play out in narrative constructions about scientists in the galleries?
(c) How do narratives about gender and sexuality contribute to or contradict the overarching narratives within the space science galleries?

Furthermore, a second thread has emerged as woven through the Introduction and Literature Review I have presented thus far. This thread is that understanding what is ‘there’ allows development of a critique and understanding of what is not present. Indeed, even in drawing together thoughts for the reader to direct towards the first question of this thesis, questions about what the ‘proper’ realm of STEMM museums is, or what professional STEMM careers might look like were touched upon. The general absence of literature attentive to sexuality in science museums (beyond medical collections) was a point of departure for thinking about what else might be overlooked, hidden, or deliberately removed from the discourse in these gallery spaces. One reason that I have iteratively developed this question was that the very premise of the first question of this thesis is about understanding quiet but persistent narratives constructed in these spaces, from an initial interest of a queer feminist perspective.

As a doctoral researcher, I know that my understandings of both queer feminist approaches and their intersections have developed during my research, and even at this time of submitting, I do not have a fixed position nor a stable identity as a researcher.
Indeed, one of the most important learnings I have learnt from my research on queer theory is the inherent instability in identity, and the ability to make and remake ourselves in new relational situations, and under new constructs. Thus, while I approached this thesis with a grounded, intersectional, queer feminist approach, looking for the absences or ‘gaps’ within the gallery has helped me develop a reflexive praxis as a researcher, challenging whether I think that issues that arise from these silences can be grappled with from my positionality. Furthermore, drawing on Ahmed’s Uses of Queer, thinking about absence as the destruction of meaning making, or the gap within acceptable and accepted narratives, this attentiveness through using queer shows the “creativity of queer use [as] an act of destruction, whether intended or not; not digesting something, spitting it out; putting it about” (Ahmed, 2018).

I have also demonstrated how previous critical approaches to other theoretical areas have highlighted how values have been overlooked or not included in scholarship, and considered what the implications of constructions are. For instance, Yosso’s (2006) articulation of types of capital that are overlooked within the framework of Bourdieu’s capital, Fowles’ (2016) understanding of how objects are made to speak in the place of human subjects of previous anthropological work, and Dawson and Jenson’s (2010) critique of Falk’s museum visitors identity model allow me to broaden thinking about what knowledge is not being valued within the galleries I’ll be looking at. One of the reasons my literature review covered representations of space science in popular culture, as well as gender and sexuality in other arts and socio-historical museums, is to provide a point of contrast to the galleries that I will be studying. Yosso, Fowles, Dawson and Jenson are linked by being able to point to ways in which existing scholarship does not attend to the lived experiences or narratives they see in their own datasets.

As an additional thought about the value of describing the absence, I introduce theory on working to construct anti-racist spaces in education. So much in education (public and formalised) is institutionally racist, that unless we are actively working against racism –
working hard on doing actively anti-racist work in your education environment, a tiring and relentless project – we are still racist because we perpetuate structurally racist ways of being in educational environments. Structural racism intersects with and is inflected by sexism, hetero/homonormalism, and ableism, and should never be considered monolithic, but rather multiple. By attending to the mechanisms that we tacitly accept within the museum that construct absences, we may better understand how to take active steps against these elisions. Some of these may be racist reproductions, others may be gendered, queered, colonial, ability-based norms; silently imbedded and unchallenged within the gallery spaces. The development of ways to articulate norms that are upheld both by what is included and what is absent is vital for thinking about ways in which these norms can be challenged – how we can actively work against structural racism?

In other words, understanding what is inscribed into gallery narratives allows us access to knowing about values, power and knowledge in these spaces. In Beard and Henderson’s 1991-2 intervention in the Ashmolean Museum’s gallery, *The Curator’s Egg*, the subversive questioning of the exhibition granted an “exploration within the museum’s own culture and language: an exploration of the values, the claims to value, the legitimation of value” (Beard & Henderson, 1994, p.8) that happens within an exhibition itself. In fact, many of the exhibition interventions that I introduced earlier in the literature review in Section 2.2.3.2.3 addressed the absences in galleries through drawing attention to them – these may be about queer lives, gendered lives, racialised lives, or colonial narratives – and in a variety of different ways. All make critical commentary on why particular narratives might be absent – and are summarised in Mason and Sayner’s (2019) essay detailing eight ways that silences might be approached in museum spaces.

Thus, without expectation about what I might find by doing so, my second research question is:
Question 2: By being attentive to the presence of the curated gallery space, what is absent in the gallery?

Again, to help scaffold some of my thoughts on this material I posit three subsidiary questions:

(a) How do the absences construct or challenge narrative construction of these galleries?
(b) How can these silences and absences be read?
(c) What might perceived absences in the gallery illuminate about a perceived audience or perceived audience expectations?

Finally, embedded within a queer feminist praxis is my motivation not only to elucidate but also tackle and develop ways to address the challenges that arise in the research I do. I believe that two themes that have run through my literature review are pluralising methods of approaching concepts, and understanding how developments bring additional, valuable knowledge to these spaces. This thesis, thus, will deflect attention from just the ‘centres’ of ‘official’ knowledge (the museum galleries) towards the peripheries by introducing space for possibility within these galleries by placing importance on the ‘popular’ knowledge that demonstrates and documents alternatives.

In considering pluralising approaches, I am directed by Olufmi’s (2020) conception of feminism as a project about what could be, an active body of thought that directs the power of speculative potential. Thus, having addressed what is in the galleries, what is/are the speculative or practice potential(s) of this queer feminist approach, and how could we understand them in action, I articulate of the final research question of my thesis:
Question 3: Through understanding these inclusions and exclusions as exercises of power, what are the roles of ‘alternative’ approaches to power, identity, and futurity in the museum gallery?

To detail this further, I shall utilise the subsidiary questions:

(a) What ‘alternative’ approaches could be possible in museums?
(b) How do these approaches engage, challenge, and/or disrupt existing narratives?

2.6 Summary

In this chapter I have introduced grounding literature across understanding ‘space science’, the development and various theorisations of museums in general and STEMM museums in particular, the roles of understanding learning through pedagogy and curriculum expansively in the context of the museum, and the importance of thinking through gender, sex, and sexuality. Finally, I drew together threads from across the Literature Review and the Introduction, culminating in my articulation of my research questions. In the next chapter I will lay out my methodology and methods, before moving on in subsequent chapters to the analysis and discussion of my data.
Chapter 3 Methodologies and Methods

Drawing on research from across Museum Studies, Education, Science and Technology Studies and Cultural Studies, my thesis will use a selection of methods and frameworks to understand and interrogate the gallery spaces. These are, From the Beginning at the Natural History Museum, Exploring Space at the Science Museum, and the Weller Astronomy Galleries at the Royal Observatory Greenwich Informed by my research methodology, expanded on here from my Introduction, these methods will help me build an analytic understanding of the contents and absences of the museum galleries that are the subject of this thesis.

In this chapter I will briefly recap the methodologies from the Introduction, to bring to the fore the theoretical approach I take in my research. I will then explore the different frameworks used in my data collection and interpretation. Here I will also explore and justify the adaptations I have made from the way that the original frameworks were conceptualised based on my queer feminist methodology. Following this, I will explore the three galleries that make up the data set of the research, and briefly explore their histories and constructions. The chapter will conclude with an outline of some of the difficulties I encountered in developing the methods for this research, and I will explore some of the limitations of the methods used and the data set. Finally, the chapter closes with an exploration of some alternative methods that could have answered adjacent questions and may be valuable for further study. I will return to these alternative questions in the concluding chapter of my thesis.
3.1 Methodology/Methodologies?

During 2018 I saw a *Guerrilla Girls* exhibition – a critique of the art world’s masculinity and whiteness – but was particularly struck by the use of the gorilla masks by the group. Yes, this critique was a timely challenge to the hegemony of the art institution, but I was interested in exploring who might feel comfortable dressed as a gorilla even if it was in aid of drawing attention to the problems the art world posed. Thus, the conceit implicit in the exhibition of a point of feminist criticism contained within it a “particular academic arrogance to assume any discussion of feminist theory without examining our many differences” (Lorde, 1984, p.1). Indeed, a monolithic conception of ‘feminism’ or ‘women’ which can be seen to rise in public narratives – attempting to dismantle a system that is structured against these neatly formatted ideas of what those categories could be – retains the very problem it seeks to address and creates “the same evasion of responsibility, the same cop-out, that keeps Black women’s art out of women’s exhibitions” (Lorde, 1984, p.3).

Lorde’s critique of the difficulty (or impossibility) of structural change that relies in its actions on solidarity around the very categories created by the patriarchal structure was reflected back to me in a different way in Cheng’s *Ornamentalism: A Feminist Theory for the Yellow Woman* (2018). Rather than think about the exclusion of identities within a gallery space, this paper asserts subjectivity of both the experience of, and narrative construction around, women of colour by the white discourse particularly in museums:

> The tying of ornamental artifice to Asiatic femininity in Euro-American visual and literary cultures is ancient and enduring ... Asiatic femininity is, above all, a style ... [where] Oriental female objectification is refracted through the lenses of commodity and sexual fetishism. (Cheng, 2018, p.419)
As Cheng highlights in her argument, the discursive narratives around Black women and Asian women is different again – and cultural institutions play into and perpetuate these as discrete narratives. Read against the ‘primitive’ constructions of Blackness in exhibiting Black women (including, for instance, Saartjie “Sarah” Baartman), the delicacy and decorative nature of Asiatic femininity is propagated differently through the fantastical nature of the subject of the paper, the *China: Through the Looking Glass* exhibition at the Metropolitan Museum of Art (New York), artefact and commodities in place of bodies and voices, reconstructing an Oriental view of ornamental femininity (Kassim, 2020; Said, 1979). The exclusions and systematic treatments of ‘groups’ of women and femininity differently in the museum dependent on perceived identity speak to my work to intentionally pluralise my feminist methodology.

Coincidently, I read Cheng’s text in tandem with two events: the news of the Chinese Space Agency’s Chang’e Lunar Lander touching down on the far side of the Moon, resurfaced news about Chinese astronauts, space ventures and training sites in UK news media, and the introduction of the Japanese-European collaborative orbiter BepiColumbo’s engineering model at the Science Museum. In both instances the focus on objects and artefacts over and above voices of those Chinese and Japanese workers involved in either project echoed Cheng’s theorisation of the emphasis of the object as ornament rather than related to a person. The articulation that it was not only the subject of the exhibition that was important, but also the perspective of the visitor, the knower, Cheng herself in that gallery space, pushed me to be more explicit to the reader about who is doing these readings in my research.

Drawn out from these two examples, then, is my attentiveness to ways of being; being *in* the galleries, and being and knowing *about* the galleries are implicitly co-constructed. Knowing about being in the galleries shapes my understanding of galleries when I return in the future. In approaching articulating my methodology, I thought not only about the construction and understanding of knowledge in my thesis about the text, images, and
diagrams relating to the galleries in this thesis but also about the materials I produce around the thesis. These materials spans work that can be found in my impact statement, online, with whom and how I choose to collaborate to disseminate or create new knowledge outside the context of this thesis. To me, to do queer feminist work is not just about the subject matter and the modes of research; the methodology extends into my ways of being and knowing in the wider world too. Cheng’s and Lorde’s work directed my attention to thinking through exhibitions before developing interventions, to articulate aspects that otherwise might have been invisible to me in constructing work with publics, and about the value of thinking through doing work alone before collaborating.

3.1.1 **Queer feminism?**

Both ‘queer’ and ‘feminist’ methodological situatedness can cover a multitude of positions. Moreover, the intersection of these two fields of scholarship is multifarious and plural in itself; thus, to articulate my ‘queer feminist’ position also deserves attention, as described in my Introduction. In this section, I will be exploring the ways that I understand and bring these perspectives to my research and the writing of this thesis, and where these have developed from. Recounting a genealogical history of queer or feminist theories is a contentious task. Not only are there multiplicities in both fields, there are also different and (sometimes) discordant narratives too (e.g. Jagose, 1997; Richardson, 2006; Sedgwick, 1990; Sullivan, 2003; Turner, 2000; Warner, 1993; Weed & Schor, 1997). A genealogical approach aligns somewhat with a progress-inflected narrative, which is also problematic in its suggestion that contemporary feminism is ‘better’ than that of the past. I have instead started and will continue to use the approach of *Molecular Feminisms* (Roy, 2018), drawing together these strands of theory in my work in the orders in which I encountered or they became important to me.
Some of the material which might ordinarily sit in this methodology section of a thesis was included in my Introduction instead. I moved the discussion about theory and tensions in doing my research earlier in the thesis as I felt it would have been to mislead the reader to assume that even my initial steps in the text were un-guided by the methodology that underpins the rest of my research. Thus, it was to make explicit that the literature review and the questions that my research seeks to explore – as much as the rest of the analysis – were informed by the choices and understanding of a queer feminist methodology. To recap, in my Introduction, I explored key queer feminist questions that inform the approaches that I take in my research. Explicitly these are, who is doing ‘science’, what is ‘science’, who decides who is doing ‘science’ or what ‘science’ is, and how doing, being, and knowing things co-construct the ways in which we perceive the world. Additionally, in the Introduction I wrote about my positionality as a researcher. Much like my methodology, this is not an identity or perspective that I (can) shed on sitting down to write the text of my thesis; thus, I felt it was important to foreground this rather than leaving the discussion to this chapter.

Understanding that researchers have methodological perspectives was something I have learned along with learning about having an ontological and epistemic position in relation to the world at large and the data for research in particular. As a scholar with training in physical sciences, the idea of thinking about knowing, knowledge, and knowers was not something I had spent a long time reflecting on. As such, it has been interesting for me to see a progression in my own reflexivity about (my) methodology, ontology and epistemology over the course of my doctoral research. Visibilising the changing nature of my understanding of the world through my writing and research also encourages me to think that my ways of knowing and thinking about the world are likely to continue to change with time – it is unlikely that I have reached my final state of understanding how I know about the world simply because I am writing my thesis. Thus, it is important to me to make strange even the concept of writing with certainty about the ontological and epistemic positions undergirding the research I do – and to be explicit about how the
relational and changing nature of myself and my research are likely to continue to change, shape and develop. My being and knowing are part of an ongoing co-orbit that develops over time.

Viewing my own shifting methodology over the course of this research echoes much of the contingencies of queer feminist methodology discourse more generally. As has been described elsewhere, schools of queer thought draw on poststructuralist and postmodern theorists but are, unlike feminist, anti-racist or postcolonial scholars, “less inclined to consider the implications of these approaches to methodologies and methods” (Browne & Nash, 2017, p.1). But, if the understanding of queer as constructing “tenuous and fleeting subjects”, particularly on the basis of sexual/gender identities or of doing anti-normative work, the collection of data on any subject’s being might in itself be “only momentarily fixed and certain” (Browne & Nash, 2017, p.1). How can queer theory not be implicated in the (re)theorising, (re)conceptualising, (re)expressing of methodologies as well as methods? As such, understanding queer, or queer feminist, theories and applying them to data is a methodological problem (Boellstorff, 2007, p.210), in as much as it is a methods problem. However, it is slippery and poorly documented – often with researchers rejecting writing about it as part of the strictures of doing anti-normative work in writing research (e.g. Curran, 2020, personal correspondence).

Much like feminist researchers including Harding (1986), asking questions about science though queer feminist epistemic lenses helps challenge the ‘unassailable’, ‘objective’ researcher – instead drawing out “a knowable reality through reliance on a relational theory of truth” (Browne & Nash, 2017, p.4). Queer then helps us think even further about the nature of subjects – contingent, plural, multiple, unstable, and constituted within specific social, geographical, and historical relations – making attributes of the self (such as sex and gender) social constructs rather than biological certainties. However, across social sciences there are ways in which these conceptions of subjects, objects, social lives, methods, and methodologies “overlap and are engaged in mutual and contingent
constitution” (Browne & Nash, 2017, p.10). Indeed, feminist theorists dispute the concept that in and of themselves, methods (quantitative or qualitative) do not have ontological or epistemological qualities, but it is their use in relation to a methodology that creates feminist knowledge or otherwise (e.g. Maynard, 1994; Stanley, 1990; 1997). However, I perceive this to be a strong position to take – there are methods that are themselves predicated on particular ontologies and epistemologies about the knower, the subject, and the ways of recounting knowledge in research methods, that are embedded with notions of truth and authenticity (e.g. Haraway 1991; Harding, 1986; Hesse-Biber & Leavy, 2008). Is there some underlying understanding in working on queer approaches about what methodologically makes some approaches queer? Is it to do with the knower? The subject matter? The methods? All of these – or a bricolage of any of these at a time? I do not have the answers on these, but think they are valuable points for me to reflect on, and return to regularly through the research project.

Holding in hand some of the problems that I encountered theoretically when exploring ‘queer’ in relation to methodologies, epistemologies or ontologies, I will lead the reader through the ways I have used feminist perspectives, and how it might be possible to think about bring these into conversation with queer theories. Feminist epistemology can be understood to seek to redress the disparity of dominant modes of knowledge that create disadvantages along the lines of gender. The disparities that are addressed by feminist research are seen as epistemic failures of existing conceptions of knowledge, knowers, objectivity, and subjectivity. In particular, thinking in relation to scientific practices, these disparities are seen in (but not limited to) actions such as exclusion from research, denial of epistemic authority, denigration of styles of knowing, theorising women as inferior to men, invisiblising women and their activities or interests, and by developing knowledge that is not useful to those in subordinate positions. Feminist epistemology helps me understand there is no view from nowhere (Haraway, 1988; Nagel, 1986), no value neutral position to take on material that is produced, displayed, or celebrated. Not only is my
knowledge for this research situated in relation to what else I know, but also to other knowers.

Crenshaw’s (1989) foundational text on intersectionality asserts the essential importance of the understanding that not everyone is similarly situated: that individuals who experience multiple marginalisations or minoritisations by society experience the sum of them differently to how others experience the discriminations individually. Intersectional challenges to equity are made manifest in a number of ways, and expanded upon in many directions. We can see them structurally through “multi-layered and routinized forms of domination” (Crenshaw, 1989, p.1245), and attending to different sets of intersecting marginalisation shapes different strands of theory. The lives of Black women and girls and centred in Black Feminism (e.g. Brah & Phoenix, 2004), queer of colour theory situates the knowledge and experiences of LGBTQ+ people of colour at the heart of understanding (e.g. Ferguson, 2004 ), feminist disability studies prioritises approaching disability from the lives and lived experiences of women and girls (e.g. McRuer, 2006).

3.1.2 Queer feminism methodologies in public narratives?

In the context of museums, intersectional structural inequality is made manifest through barriers to entry including opening times, locations, the structure of ticketing (for example for families), costs and types of food, drinks, items in the shops, inaccessible routes through the museum, bathroom and changing facilities, as well as structural disparities on how particular artefacts in the collection may be stored and displayed. In my literature review I previously highlighted some other scholars who have addressed, for instance through systematic documentation, the structural inequalities in museums (for example, Dawson 2019, Dawson et al. 2019). This can also be seen in museums in the political assertions that are made about what ‘belongs’ where. For instance, the inclusion of only medicine from western traditions, or a medical perspective in galleries that pathologizes disability, assert political narratives about knowledge and about the way
bodies ‘should’ be (Dodd et al., 2010). Finally, intersectional injustices can be seen in the representation within spaces too. These are multifarious, and span ideas about which images we see, how it is acceptable to dress or present in public, body language or the way that one carries oneself, or the accents or patterns of language of our voices.

I emphasise that people with different identities interact differently in different spaces, challenging the idea of ‘power’ as a monolithic, stationary experience. Instead, I hope through this thesis to begin to make explicit power and the oppression it produces as constantly in a state of negotiation and flux, with structural, political, and representational change both within and between different groups of individuals. I locate a tension arising at this point. Focusing on an ethic of responsibility and action, by capturing and articulating particularly views of the world, am I reinscribing it as the case? Thus, in exploring some of the challenges of using queer feminist theory, I have included my thoughts at the end of this chapter where I am overtly grappling with the contradictions that arise when trying to endorse particular methods or approaches. Inflecting these with queer theory as I have done in this thesis is to reflect the situatedness of the knower, the relation to the subject, and the situatedness of these relationships.

Thus, my thesis will draw on a methodological patchwork (Cartwright, 1999). I recognise and celebrate the importance of situated knowledge – what I understand in this research will be different to what other people see in the research questions, the data, in the analysis, in the discussions I undertake. In light of thinking about the social, historical, and geographical contingency of knowers and knowledge that queer urges us to take seriously, I believe it is also valuable to be explicit that my conclusions and ideas will undoubtedly change over time. This future-retrospective thought on the subjectivity of all knowledge I am creating perhaps also help explore an approach that rejects binarized positions of being. Although my research questions are predicated on understanding presence and absence, there is a tension with how ideas, events or experiences are partially there or may be implicit within local and grand narratives constructed in the museum.
The outcome of my unresolved, ongoing, thinking about epistemology has implications both for how I think about how I research in my doctoral research and writing, and also in my understanding of the galleries. Jasanoff and Kim (2015) argue that the imaginary of what is sociotechnical requires stabilisation in policy documents, legislative rules, political debate and public discourse in places such as museums, but this implies a singular, stabilisable sociotechnical imaginary. Using a methodological approach that rejects the binary, I posit that the imaginary is both stabilised and created in these spaces of public media. Thus:

In this sense, ‘worlds’ are not formed in the mind before they are lived in, rather we come to know and enact a world from inhabiting it, from becoming attuned to its differences, positions and juxtapositions, from a training of our senses, dispositions and expectations and from being able to initiate, imitate and elaborate skilled lines of action. (Anderson & Harrison, 2010, p.9)

Being and knowing are co-constructed, co-developing, and non-binary. Queer feminist approaches help me think through the implications of such ideas, which will be expressed further in this thesis.

3.2 Methods

3.2.1 Study settings

This study takes three permanent, free galleries in London science museums as the central units of analysis of this study. I shall briefly introduce each of the galleries here. In looking for galleries that I was going to involve in this thesis, I had three criteria. Firstly, I looked for museums that had a collection on space and/or space science. I was particularly interested in science and technology museums, over and above arts and socio-historical
collections, as these collections have been historically the subject of less research on the construction of the (gendered, sexualised) narratives and imaginaries of the spaces as discussed in my Literature Review. Moreover, a benefit to choosing space as a subject matter that was perceived to be a ‘hard’ science (and therefore, something that could be discussed ‘objectively’), but it is a topic that spans physical, mathematical, medical, engineering, and technology topics, which have been theorised differently in the museum at different times. The second criterion was that the gallery space needed to hold a number of elements within it that pertained to space science, not just a single object. The third was that the gallery was a permanent, free, display on space science. As illustrated in the Literature Review, often museum studies focuses on the development and display of temporary spaces, many of which also require a fee to enter. This thesis by contrast seeks to look at galleries that are free and have longer lives (at the moment, one has existed in something close to its current iteration for some 38 years), as there will be more individuals who see them. In particular, these galleries are visited by a range of visitors including school children, family groups, other educational groups, and adult visitors; they may be repeatedly visited by many due to their long duration.

The Weller Astronomy Galleries (abbreviated in this thesis as ROG-WAG when used to cite elements of the gallery) are a series of three galleries at The Royal Observatory Greenwich, itself part of the Royal Museums Greenwich (Royal Museums Greenwich, 2020). In addition to the gallery spaces, there is a planetarium (fee charging), a workshop space (booking required), a café (run by Benugos), and a shop located in the old Observatory. The Weller Astronomy Galleries are located on the same floor that you enter the building on – located at the top of a hill in Greenwich Park in south east London. Completed in 2007, the galleries focus on observational astronomy. There are three gallery rooms as part of the gallery; each tackles a different idea: Astronomy Questions, Astronomy Explores, Astronomy Inspires. Each gallery has a small introductory text inside the room. The gallery design stretches through the three galleries and the entrance space to the building: black with white, grey and blue accents.
The From the Beginning Gallery (NHM-FTB in gallery element citations) was completed during the 1995-7 redevelopments of the Natural History Museum following its expansion into a neighbouring museum (previously the Natural History Museum and the Geological Museum had been separate), situated in South Kensington. From the Beginning is on the first floor of the museum, accessible by staircases at either end of the hall, and a lift. From the Beginning is part of the series of galleries about the Earth Sciences, and wraps around one side of a three-floor central gallery, where a large escalator passes through the centre of a giant model of Earth. As this central space is also concerned with ‘space’ (broadly constructed), I will also talk briefly about this space in the thesis. From the Beginning can be split in two, the first part about planetary sciences, the second about the geological and biological development of the Earth. It is the first part of the gallery that will be the subject of this research, where there appears not to be a thematic cluster but rather a spatial narrative moving from the outer solar system towards the Sun through the gallery itself. The colour scheme of the gallery is black, with block colours (yellow, orange, green, blue, red) as accents through the use of lighting and back lighting exhibits within the gallery.

Finally, the Exploring Space Gallery (SM-ES in gallery element citations) at the Science Museum will be the third gallery considered in this research. Initially opened in 1986, the gallery has gone through small scale redevelopments where portions of the gallery have been worked on over the time since then, most recently in the summer of 2019 in the advent of the 50th anniversary of the Apollo 11 Moon landing. The gallery currently has four thematic areas, on History of Space Science, the Soyuz Capsule and Tim Peake, astronauts in space, and planetary missions, and a small temporary exhibition space which at the time of writing houses a display on the Skylark Rocket. As the display on Skylark is changed semi-regularly, I have not included this gallery in my analysis. During the course of data collection on this gallery, the Soyuz Capsule and Tim Peake section was installed (Summer 2019) replacing the some of a previous section on the Future of Space. As I had
collected data on this section in my pilot data collection, I will include some of this in my discussion and analysis. This exhibition is also black, with accents in a yellow colour throughout the gallery.

I have selected these galleries because I am interested in the local articulation of a sociotechnical imaginary of space science. Jasanoff and Kim (2015) view these sociotechnical imaginaries as a national construct, which suggests that the articulation of galleries within the same nation would be key for useful and profitable consideration of how a field is constructed and received within the same environment. For consideration then, were museums in the UK and not, for instance, the National Air and Space Museum as part of the Smithsonian. I selected galleries in London as it was also important to me to be familiar with cultural ecosystem in London, which would provide a tacit knowledge about other galleries, exhibitions, innovations that are occurring over the time of this exhibition, to help reflect and situate this research in a broader context. As a result of these considerations, I did not study galleries at other institutions. While the National Space Centre, Leicester (NSC) holds a permanent collection of materials on space science, the NSC currently charges fees for entrance visitors to the gallery. Similarly, having a floor of interactive materials on space science but also charging entry fees was We the Curious, Bristol. The National Museums Scotland (in Edinburgh) have recently renovated their Science and Technology Galleries, which provide a number of interesting points of analysis with respect to a contemporary articulation of curation of science in a gallery with an identity focus. I have, however, elected not to bring this gallery into the comparative analysis primarily because of it only having a very small section (a panel) on space science within a much larger gallery on science, which would have made comparison to galleries specifically on space science difficult. Finally, whilst the Manchester Museum of Science and Industry does host an Air and Space Hall, the gallery places a significant emphasis on air travel, with far fewer materials on space.
3.2.2  Gallery methods

My queer feminist methodology urges attention to the contingent and changeable nature of the social world. Whilst Cassidy et al. argue that:

We agree that an analysis of the exhibition solely as a text can only ever be after the fact theorising, and that moving beyond this allows us to explore the contests and contingencies involved in creating *Sexual Nature*. This can also offer insights into processes of (public) ‘science in the making’ (Latour, 1987) and how these are implicated in ongoing constructions of sexuality in society. (Cassidy et al., 2016, p.216)

I argue that given the dearth of material on queer approaches to even understanding these galleries as texts this is a vital step towards understanding science in public venues. Most existing museum studies texts have little information about how the authors gather data on the gallery or select the objects in the galleries that are the focus of the theorisation. Moreover, when not working with visitor data, while there are plenty of examples of treatment of galleries at the level of the object, these rarely engage in discussion of the whole space – or the ways that different elements might interplay with each other; nor is there usually much consideration of values or judgements that might happen based on these ideas across the display in the gallery.

The purpose of this Methods section is to explicate the techniques I use to guide my close attention to the galleries. Importantly, drawing on Das and Lowe (2018) and Ferentos (2015), the methods I use will also be attentive to the absences in the gallery and how these contribute to the gallery narrative(s) and imaginaries. So, whilst the methods I use allow me to collect the data set from the gallery, later in this section I will consider the interpretive analytic work I have done to understand absences in the space and how these inform the construction and readings of the galleries.
Museum galleries are a multisensory experience that are constructed from a number of different parts, which can be understood as the knowledge network of the exhibition (Moser, 2010). Although they will be analysed in relation to each other, these parts can, for the purpose of my data collection, be broken down into five constituent parts: architecture and spatial arrangement; videos; texts; artefacts; still images; and interactives. In selecting methods for this research, I note that many theorists in museum studies look at these sections in isolation, so I have had to draw on a number of different methods from across the literature, bringing them together in conversation in this research. This may, in part, be attributed to the move from understanding the museum as a location where artefacts can be reasonably straightforwardly and unproblematically displayed (Roberts, 2014), to now being theorised as an environment where experiences happen for visitors (Falk & Dierking, 2000). In line with this, isolated understanding of artefacts, rather than viewing the experience as a whole, is a mode of analysis that favours analysing these elements in isolation. However, to understand the creation of “context, atmosphere, and ambience for displays”, it is imperative that it is not just the objects in isolation but rather “the way words, objects and pictures are combined and grouped and added to by such elements as space, light and colors” (Swain, 2007, p.217) that is considered. The use of comparative analysis will help me understand the roles of different grand and local narratives and imaginaries within the galleries, to think about who the ‘ideal’ visitor is.

3.2.2.1 Gallery space arrangements

Architecture and building spaces that house museums are not inconsequential in asserting political ideology (MacLeod, 2005; Sheet-Pynenson, 1988; Yanni, 2005). Early museum architects and designers such as Boullée were employed with the aim of creating affective responses in visitors (Paddon, 2016). From size, evocations of temples, palaces, and incorporation of new extensions, the buildings that house the galleries are a key part of the narratives of the museum. However, more than just the exterior, the interior
arrangement also shapes the types of displays and consequent narratives that are possible, especially when there is an “effort to make the collections and the museum building work together harmoniously” (Paddon, 2016, p.102). Paddon is attentive to the ways that the space can be remodelled over time, even within a single gallery, including the construction of partition walls, lighting and “the general removal and destruction of original features” (Paddon, 2016, p.100), and these kinds of changes can themselves reshape the gallery meanings and content.

Situated practice work emphasises the importance of thinking about the whole gallery as a space within a space rather than the thing in and of itself. While this thesis will primarily concern itself with the content of the galleries, there is ‘epistemological significance’ in where the galleries are situated within the museums (Moser, 2010).

Thus, to capture the spatial arrangements in the galleries I will be using a mapping to highlight where features are and how they are related to each other. Moreover, mindful of the critique of maps as presenting “a view from nowhere” (Haraway, 1988, p.189) – an enlightenment trick to create the appearance of objectivity (Kennedy et al., 2016) – I will supplement this with positioned mapping of the galleries. Based on Moser (2010), I will collect data in the space about:

- Is movement directed in the space (if so, in what way)?
- Is the space designed for an exhibition? How has the space been shaped by the display?
- What are the relative sizes of the ‘sections’ within the room? Are these sections demarked from each other?
- Consider the scale of viewing: which features dominate the spatial landscape?
- Can you see everything at once from the entrance to the gallery? What effect does this have?
• How are the smaller ‘subplots’ of the exhibition seen and engaged with in the gallery?
• What are the initial spatial impressions? Are there systematic patterns? What is the distribution of objects and/or images and/or texts?
• Consider the entrance: what is the relationship between the initial viewing and the later impressions of the gallery?

Interestingly, Nicolaisen and Achiam (2019) use a concept mapping process (from Novak & Cañas, 2008) in their analysis of the Space Missions gallery in Copenhagen to ‘map’ what is in the gallery, understanding that this method has been used in understanding museum exhibitions before (e.g. Mortenson, 2010). Concept mapping translates the structure of the gallery into a two-dimensional ‘map’ of the thematic content of the gallery. However, concept mapping in this context gives an imperfect representation of a three-dimensional room where an exhibition is situated. Whilst it subdivides the exhibition into clusters, exhibits, and tasks, this two-dimensional mapping loses any understanding about variations within a gallery in a spatial context – or knowledge constructed through visual relationships within the gallery space. As my research is interested in the relation in space as well as the relation in theme across the gallery, I thus favours a ‘mapped’ description of the galleries that emphasises physical rather than conceptual proximity.

3.2.2.2 Artefacts

Fleming’s Winterthur Model (Fleming, 1974) is one the most used and best documented models for understanding objects within museum collections. It has been successfully adapted and critiqued for different purposes and to different ends – including its use as a pedagogical tool (Blandy & Bolin, 2012), and its use as a way of documenting objects in a collection (e.g. Glassie, 1978). The Winterthur Model emphasises the artefact in isolation, and this seen through the documentation of the model’s use in understanding artefacts in
museum stores as well as those on display. Whilst useful, one of the most widespread critiques of Fleming’s model is its overwhelming bias towards understanding ‘art’ objects, meaning that in its application to technical objects it reduces their value to their aesthetic qualities (see, for example, Elliot (1994)). This critique in particular is problematic for my research as the majority of objects in science museums in general, and in space science galleries in particular, are technical objects, of one stripe or another, that are repurposed for display. The tension between their aesthetics, use, and function is a source of difficulty at the heart of science museum displays. Recent discussions by Bowell, for example, highlight the tensions in displays of artefacts based solely on their perceived affiliations with ‘great’ scientists (Bowell, 2019), which are not aesthetic features of the artefact, nor are they necessarily related to their functions.

Thus, in this research I draw on Elliot’s adaptation of the Winterthur Model which I then further adapt. Elliot reconfigures Fleming’s five sections of his framework for analysis to better anticipate uses of the Winterthur model with technical objects. Importantly, Elliot moves the ‘Value’ category away from being a point of data collection to being something that is more deeply based in the interpretive step – it comes last in a culmination of other factors about the object. Fleming’s original model also ran the different ‘steps’ across the top, and the categories for analysis down the side, suggesting to Elliot a reading of the table that implied each step should be run through from data collection to interpretation individually, rather than doing all of the data collection through observation for each object, then any secondary source or comparative work, and then drawing conclusions across the categories to understand the artefact (Elliot, 1994).
Table 1: Elliot’s grid to investigate artefacts; rotated and with adapted categories from Fleming, 1974. Table from Elliot (1994).

I will broadly use the same analytic categories as Elliot (see Table 1), including his definitions of these categories, but I also introduce a category on ‘setting’ which will help with understanding the object in the context of the gallery. This accounts for the fact that Fleming and Elliot, as well other theorists (for example, Prown (1994), Pearce (1994b), and Batchelor (1994)), have structured their models to deal with objects while having a ‘view from nowhere’ to where the artefact of their investigation is situated. In my research this ‘setting’ category will include noting traits such as barriers between the visitor and the object, lighting, approximate height of the object, positioning and orientation, relation of the object to labelling (e.g. the proximity, colour, number of labels, direction to the label), and adjacency to other objects.

These points of exploration are ideas that I have developed through my preliminary data collection. I was aware that although some similar artefacts are displayed across the galleries, there is significant differences in how they are displayed both within and across the galleries, making the inclusion of setting a useful analytic category. I include it early in the process – it comes third when reading my tables left-to-right – because these objects
are not read in the gallery in isolation. For instance, the observational ‘value’ of an object in the gallery is implied to the visitor not only through the material and construction of the object but also through how it is displayed in the gallery. The thought embedded in this idea is that a researcher can isolate their understanding of the object from the location in which they experience it belies a slight of the methodological hand. Pearce is most explicit about an appeal to ‘scientific’ quantification of these objects that legitimises this knowledge of the artefact that occurs while transforming an artefact into being a linguistic text that can be analysed, which I do not think is substantiated. However, many theorists imply that they could make ‘objective’ observations of the artefact, and that this would be the best of knowing about it.

Drawing on traditional archaeological (Elliot, 1994), historic (Prown, 1994) and scientific (Pearce, 1994b) methodologies, there is an implication that a researcher could, with the right framework, make objective observations that would then allow for objective conclusions about the artefact. For this research, I will be reading counter to this argument; instead, I will draw on the queer feminist methodological framework that I have developed to now and situate myself subjectively within the reading of the artefacts. As seen in Table 2, introducing the setting category, I will therefore be able to better articulate one of the ways in which ‘value’ is attributed to an artefact. I have additionally renegotiated the ‘provenance’ function Fleming and Elliot use to be understood as ‘history’ to think about how the artefacts have been positioned. I broadly construct this category to think about the users, makers and developers, as well as materials, intellectual and technical histories.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Material</td>
<td>Material</td>
</tr>
<tr>
<td>Construction</td>
<td>Construction</td>
<td>Construction</td>
</tr>
<tr>
<td>Provenance</td>
<td>Function</td>
<td>Setting</td>
</tr>
<tr>
<td>Function</td>
<td>Provenance</td>
<td>Use/Function</td>
</tr>
<tr>
<td>Value</td>
<td>Value</td>
<td>Value</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
</tbody>
</table>

*Table 2: The categories used for collecting data in Fleming, Elliot and my study. See Appendix A for an example of complete data table used in the data collection.*

3.2.2.3 Text

In looking at Science and Natural History Museum interpretations, Ravelli argues that the texts on display

form a central component of a museum’s communication agenda ... it is the development of the thematic exhibition, with its strongly educational goals, which has placed the role of exhibition texts at the forefront. (Ravelli, 2006, p.3)

Scholars such as Witcomb (2003) discuss how different models of understanding language can be understood in different museums and different contexts, and using unified methods that well suit disparate methodologies. Within the corpus on museum studies, there is notable trend towards analysis of the texts in the museum as pieces of data.

Some scholars utilise a linear transmission model of textual analysis (e.g. Hooper-Greenhill, 1994), which might be more closely aligned to ideas of a deficit model of communication in the gallery space. Whilst they understand some of the necessarily didactic nature of the communication in the gallery space (it is, after all, not dialogic), they overlook the role of the visitor’s knowledge in the analysis. Other scholars (e.g. Halliday, 1978) use systematic-functional linguistics, which emphasises the importance of language occurring within a context, and that it, therefore, should be considered in relation to the context it is found in.
Beverly Serrell (2015) authored a popular guide to writing museum exhibit labels that I shall use in reverse alongside Ravelli’s framework for textual analysis (2006), and the combination of both can be seen in Table 3. While Ravelli addresses texts in a strictly analytical manner from what is in the gallery space, Serrell writes about how to use texts to construct what will be in the space. I believe both approaches will be beneficial to thinking about both the content of the labels and the mode in which they are operationalised. Much like the discussion above about the artefacts, I am using an understanding of the context (drawing on a systematic-functional linguistic approach) to build an analytic picture of the content of the gallery.

<table>
<thead>
<tr>
<th>Considering the audience</th>
<th>Visitor experience</th>
<th>Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who is the audience?</td>
<td>Hierarchies of labels</td>
<td>Typographic design</td>
</tr>
<tr>
<td>Audience fragmentation</td>
<td>Modalities of labels</td>
<td>Production and fabrication</td>
</tr>
<tr>
<td>Reading level</td>
<td>Images and words working together</td>
<td>Images</td>
</tr>
<tr>
<td>Number of words</td>
<td>Labels that ask questions</td>
<td>Location of text panels in relation to the artefact</td>
</tr>
<tr>
<td>Multilingual labels</td>
<td>Labels for interactive exhibits</td>
<td>Location of text panel in relation to gallery</td>
</tr>
<tr>
<td>‘Visitor-friendly’ labels</td>
<td>Digital interpretive devices</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Framework for collecting data about texts in the museum used this research, developed from guidance in Serrell (2015) and Ravelli (2006).
In contrast to these methods that I have used, there is a distinct educational and sociological strand of museum research that relies on understanding the visitor experience of the text – i.e. from a reading perspective rather than a writing perspective. These researchers, whose emphasis is on understanding the experience of the visitor(s), work with visitors to understand their response to the text that is in the gallery. This is done through ethnographic work, through interviews or through focus groups with visitors on their trips. For example, Dawson addresses texts in the museum in relation to the interaction that the research subjects have with them (2019). These techniques provide different knowledge to the researcher about the ways that information has been received, rather than the content it is set up to contain.

3.2.2.4 Interactives

In my literature review I covered the parallel literatures around science museums and science centres or interactive science spaces. While there is argument that these are distinct spaces (Schiele, 2008), all three of the galleries that are the subjects of this research contain interactive elements; these are integral to the ways the galleries are constructed.

In a recent review of the literature, Dancstep and Sindorf (2018a, 2018b) have addressed measures for understanding how to understand, assess and develop interactives that engage young people. Pertinent to my research, these authors frame their research work within an “effort to address gender inequity in science, technology, engineering, and maths participation” (Dancstep & Sindorf 2018a, p.469), given that previous research (such as that by Diamond, 1994; Girls Inc., 2004, Greenfield, 1995; Hill et al., 2010; Kremer & Mullins, 1992; Lee & Burkam, 1996; National Science Foundation, 2003; Ramey-Gassert, 1996; Verheyden, 2003) found that “exhibits in physics and engineering have been found to attract girls less and engage them for less time” (Dancstep & Sindorf,
Dancstep and Sindorf identify four key pedagogical features of exhibits that they indicate support women and girls’ learning (although they note that these rarely lead to a decrease in the interest of boys and men in the activity), together generating the Female-Responsive Design (FRD) Framework. These are: social interaction and collaboration; low-pressure settings; meaningful connections between the lives of the individuals and the exhibit; and representation of women and girls, and their interests (Dancstep & Sindorf, 2018a).

In their construction of the framework, however, the mixed use of terms ‘female’ (e.g. “theory-driven Female-Responsive Design (FRD) Framework” (Dancstep & Sindorf, 2018a, p.471)) and ‘women and girls’ (e.g. “researchers agree that more inclusive practices are needed in order for STEM education to successfully engage women and girls” (Dancstep & Sindorf, 2018a, p.471)) is problematic for my research. Whilst Dancstep and Sindorf indicate that they are discussing gendered, socially constructed, and communally enacted practices in their report in a section on gender and sex, they continue to use ‘female’ (a designation that, as discussed before, is usually associated with biological sex rather than socialised gender) interchangeably with ‘girls’ to describe the target group of their research. Although they suggest that these interchangeable uses come from related theorists Gutiérrez and Rogoff (2003), and Paris (2012) who explicitly recognize that there are many ways to be female: preferences and behaviors related to femininity and gender vary across individuals. (Dancstep & Sindorf, 2016a, p.472)

I argue that this is insufficient, especially in light of a queer feminist understanding of gender as distinct from sex. As they indicate this work is about gendered performances, and mine is too, I shall, from henceforth, be using the terms ‘girls’ and ‘women’ in the discussion of this paper. However, although they suggest at one point that the FRD Framework is designed to support engagement of ‘all genders’ (Dancstep & Sindorf,
suggestion of other social genders – I cannot see evidence in their writing of such engagement. This is especially clear in their fourth pedagogical strategy “Represent Females and their Interests” (p.474), where this is no mention of other underrepresented genders. As a result of these critiques, I will in the text that follows discuss how my research will adapt the FRD Framework as it provides a useful summary of much of the previous literature in order to better reflect my methodology in the grounding of my research.

I particular, as is seen in Table 4, I have reframed the call for representation of women and girls in the original framework as being about the relevance to the viewer, thinking critically about who is depicted, the use of role models and self-image, the types of interaction and formality in the gallery setting. As I will return to later in the analysis, the gendered constructions of, for example, particular skills or aesthetic types are flexible in time and geography and between social groups. Rather than assuming that particular skills are gendered in particular ways (as has been done in the FRD), I have set up my framework to understand which skills are required and move from there in the analysis to think about how these traits (aesthetic types, skills etc) are operationalised within the galleries.

<table>
<thead>
<tr>
<th>Social Interaction and collaboration</th>
<th>Low pressure setting</th>
<th>Connection</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many people?</td>
<td>What to do from a distance?</td>
<td>Real world context</td>
<td>Who is depicted?</td>
</tr>
<tr>
<td>How many at the same time?</td>
<td>How to engage close up?</td>
<td>What is the context?</td>
<td>Are there role models?</td>
</tr>
<tr>
<td>Method of working with others</td>
<td>What type of exploration?</td>
<td>Story or narrative</td>
<td>Self-image</td>
</tr>
<tr>
<td>Instructions or encouragement for discussion</td>
<td>What are the goals of the exercise?</td>
<td>Authorship of the objects/narrative</td>
<td>Aesthetic types</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------------------------------------</td>
<td>-------------------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Language</td>
<td>Instructions for interactions</td>
<td>Other</td>
<td>Informality</td>
</tr>
<tr>
<td>Label voice</td>
<td>Other</td>
<td></td>
<td>Types of skills and interest</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

*Table 4: Framework used for interactives in this research, developed from Dancstep and Sindorf (2016, 2018a, 2018b).*

### 3.2.3 Archival methods

Although my research is focused on the contemporary presentation of the galleries at the time of the data collection, I have undertaken archival research where possible to support the mapping of the gallery, and to further inform the historical construction and influences in the making of the galleries. The histories of the galleries shaped my access to the materials available; while plans and documents from the Science Museum and the Natural History Museum were available in their respective archives, much of the documentation relating to the Weller Astronomy Galleries had not been accessioned to the Royal Museums at Greenwich Archives (Devoy, personal correspondence). Despite communications with the curators of the Weller Astronomy Galleries, I was unable to access documentation around their development. To supplement the materials in the archives, I have also spoken to the current curators of two of the three galleries: Exploring Space and the Royal Observatory Greenwich. As the contents of the archive are a site of contestation about what is of value for collecting and categorising (Ketelaar, 2001; Singh, 2019), and are inevitably incomplete (Muñoz, 2009), I have both used the archives and these conversations as a point of reflection in my research. Through the text of this thesis I will draw attention to the use of some of these materials in the development of the
analysis, and draw on previous theorists who understand collections through the institutions in which they are embedded (e.g. Alberti, 2005).

### 3.2.4 Survey methods

After the delivery of the Queering the Science Museum tours, we encouraged participants to complete a survey of the tours (Appendix B). Whilst the survey was sent to everyone on the tours (n=113), only a sample of the participants completed the survey (n=23). It is likely that the participants who answered the survey skew towards being personal contacts of myself and the other tour guide, or those with particularly strong opinions on the tours that we delivered. It is difficult to know if the sample accurately reflected the population of the tours in terms of gender, age, and social background as we did not collect these data on the whole group (the tours were free and only required the participants to show up on the day rather than register in advance). It is likely there were interviewer effects because, although the questionnaire was administered anonymously online, the participants on the tour had met myself and the other tour guide on the tours, and our race (e.g. Hill, 2002), gender (e.g. Flores-Macias & Lawson, 2008) as well as physical appearance (e.g. Eisinga et al., 2012) are likely to have influenced both the rate of completion and the content of the responses.

The survey used an online questionnaire format (Mellenbergh, 2008), with a link being distributed through emails and messages to attendees. The survey took a cross-sectional approach as the relevant population was only surveyed once (Shaughnessy et al., 2011) and allowed characterisation of the sample at the time rather than providing any longitudinal data. The questionnaire was developed and tested with members of the trial tour group (Shaughnessy et al., 2011) and revisions were then undertaken to clarify some of the questions, and to edit the ordering of the questions such that demographic information was collected last. This was important as we wanted respondents to feel that they could express their opinions on the tours without self-censoring as a result of identifying as
LGBTQ+ (or not) (McInroy, 2016). Trial respondents were not included in the sample (n=23) on which analysis was undertaken. The majority of the questions about the tour were open-ended, and addressed motivations, and existing knowledge of queer heritage in STEMM, as well as asking about what they perceived was absent or what was lacking on the tour.

3.2.5 Methods of analysis

The qualitative data I have generated in these methods of data collection provide good descriptions of phenomena (Sofaer, 1999), which is particularly useful in research with novel, poorly understood phenomena (Hurley, 1999). I have drawn on a grounded theory approach (Savin-Baden & Howell, 2013) to undertake my qualitative analysis. I have taken a primarily constructivist approach, understanding that theory is not ‘discovered’ from the data, as was argued in early formulations of grounded theory, thus rejecting the notions of early theorists like Strass and Corbin (1998) that:

[an objectivist grounded theorist assumes that data represent objective facts about a knowable world. The data already exist in the world; the researcher finds them and 'discovers' theory from them. (Charmaz, 2006, p.131)]

Instead, I work from the premise that theory is biased by the researcher (me) and my epistemic and ontological commitments. Importantly, I do not understand research analysis as unidirectional, but rather an ongoing interaction of the researcher and the world (Charmaz, 2006). This constructivist approach to understanding grounded work with data is inflected with strands of feminist grounded theory that recognises multiple realities and centres analysis of privilege and power (Keddy, 2006; Kushener & Morrow, 2003; Wuest, 1995), as well as a postmodern approach that emphasises noting absences from the dataset (Clarke, 2005), and thinking with the literature (St Pierre, 2014). Throughout the analysis of my data I have iteratively thought carefully about the
credibility, originality, resonance, and usefulness of the results from the analysis (Charmaz, 2006), demonstrating the fundamental practice of grounded theory of making sure data analysis and collection “intertwine continually” (Glaser & Strauss, 1967, p.43). While undertaking this process, I have been thinking critically about the point of ‘theoretical saturation’ – the suggested completeness of the grounded theory approach – in relation to a queer feminist methodology that rejects a notion of a static end point of research. Thus, while I have enough data to validate the themes and arguments of this piece, I reject the notion of the ‘completeness’ of any given category.

There is some use in the literature of grounded theory approaches in gallery research; for example, Haywood and Cairns (2006) used it to understand engagement of children with (primarily digital) interactive exhibits at the Science Museum. Wood and Wolf (2008) also used grounded theory to look at the various tones and features of museum visitor engagement, to understanding different visitor behaviours to explore the gap between the expectations of educators and the actions of families. Paddon (2014) used grounded theory to understand themes around museum architecture from the visitor perspective. Most of these uses in the museum context employed interviews to gather data, but elsewhere in grounded theory literature this analytic method has been applied to ethnographies, documents, and texts and thus it has been used as I shall (see, for instance, Charmaz, 2006).

In addition, I have drawn on literature on thematic analysis, particularly reflexive and qualitative thematic analysis that takes a similar constructivist approach to Charmaz’s (2006) conception of grounded theory. My use of thematic analysis guides a focus on how social objects, such as concepts of gender, are represented and constructed in the gallery, focusing on what is being depicted. Using Gibbs (2007) and Braun and Clarke (2013), I have undertaken thematic coding of the galleries, developed comprehensive themes and found relevant extracts to collate into the analysis. I ensured that the themes I generated are internally coherent, consistent, and distinctive; importantly, from a
constructivist approach, I have been attentive to how my work as a researcher has generated these themes. This approach to thematic analysis has been used elsewhere in museum gallery studies, such as in Nicolaisen and Achiam (2019), where studying how expected identities of visitors are constructed within the planetarium by looking at the content of the galleries took a thematic analysis around gendered constructions.

3.3 Difficulties and limitations of the methodologies, methods and dataset

I have, above, discussed the limitations of the methods I have selected as well as looking at their collective limitations in answering the research questions I have proposed. In this section I shall address some of the problems I encountered in doing this research, and the steps I took to resolve them.

3.3.1 Limitations of temporality

In an introductory course I took in my doctoral studies, we were encouraged to think of the doctorate as a space for learning to be a researcher in all senses – learning to conceive of, learning to execute, learning to reflect on, and to write up research – such that on completion we would be able to lead further research. I therefore view this section on limitations as an important part of my work. By acknowledging these, and seeing future work as part of a praxis, I reject seeing this thesis as being ‘the end’ of my research. Instead, I hope to have developed a good working understanding of critical approaches to normativity in space science galleries, to my working practice as a researcher, and limitations which any future research project I am involved in would hope to surmount.

The ability of different modes of research to allow demonstration of this cyclical process is part of the motivation to include a chapter that draws on modes of participatory action research in the development, delivery, and reflection and then redoing of a tour. In Participatory Action Research, by creating, doing, and then reflecting on the process
before doing it again iteratively, allows the reworkings of established forms of linear data collection (Kindon et al., 2008). I value the emphasis of the technique on the messiness of social life, and the place of the researcher in (re)creating it, such research can provide a place for those who otherwise tend to be marginalised, disenfranchised and excluded in the process. (Browne & Nash, 2016, p.13)

I think that it is vital, as with other parts of this chapter on methods and methodologies, that this thesis is therefore not seen as the end of my work on the subject matter. Instead, I conceptualised this project as being a starting point, a point of departure. To reflect back on Ahmed’s queer use, this might be a doorway through which to pass (Ahmed, 2019) – but one that only by having some understanding of the doorway and its limitations to particular users and uses, am I able to know how to describe the limitations of the doorway when asking others to use the door and moving forward in my own work.

3.3.2 Ethics, or working with collaborators and participants

A limiting factor to my work is that it is research being written and undertaken alone, rather than working collaboratively to understand these galleries as a function of doctoral research needs. Unlike, for example, Cassidy et al. (2016, p.220), who in their paper work as a trio having “combined [our] observational and textual analyses” to think about the gallery, providing a discursive take on distinct and differently queer perspectives, this thesis had to be authored by me as a singular researcher. This limitation is something I have addressed in working on other projects outside my thesis, where I undertake collaborative praxis (e.g. Space Science in Context, 2020; Outer Edge: Queer(y)ing STEM Collections, 2020).

I chose not to use the methods of Macdonald (2001), conducting an ethnography of the curators in one of the galleries that my research has been undertaken in. While this would
have allowed me access to information about how those constructing these spaces think about the stories they tell, and the audiences these stories are destined for, I believe it would have limited my perspective on the way that these galleries exist themselves. Taking Mott’s approach of working ethnographically with front of house teams could have allowed a different perspective on what being in those galleries continuously would have been like (Motto, 2016); however, none of the galleries in my study are continuously occupied by front of house teams. Most had security personnel and technicians in them far more frequently than any members of front of house or curatorial staff during my data collection periods. Some projects have looked at the role of the presence of security staff on visitor experience (e.g. Krantz, 2009), as a tool for social control (e.g. Trondsen, 1976) or for protection of the museum’s collection (e.g. Burke & Liston, 1993). However, security and technical personnel in the museum are an under-researched influence on the ways that visitors are in the gallery, given their ubiquity and the extensive duration of their time in museum galleries. This is particularly notable given that those occupying the roles of security and maintenance staff are from more diverse backgrounds and often experience greater precarity too. Working with such staff might present a different view challenging the passivity of Macdonald’s “tidying away” (2001, p.2) by attending specifically to those tasked with the securing and cleaning up.

Particularly in relation to the second question of what is absent from the gallery I could have taken a participant discourse approach, for example by using craft-back techniques that allow participants to create boards that illustrate and problematize the images, narratives, and discourses they are confronted with in public spaces with images and text (e.g. Ringrose & Regehr, 2017; Sprecher, forthcoming), with objects and creative interventions (e.g. Museum Remix, 2019), with tours and interventions, (e.g. El-Amin & Cohen, 2018; Anti-Tour, 2019), or simply via a text-based discussion of the space (e.g. Cassidy et al. 2016). These types of projects with non-museum workers would have provided plural understandings of what is absent in the galleries. However, my ethics of care for participants in this research project were such that I could not satisfy two distinct
challenges. First of all, I did not have money to provide materials, tools and space nor to pay participants to ensure they were fairly compensated for the time and expertise that they provided to the project (Head, 2009). Secondly, I did not know what was in the gallery myself and I believed it to be unwise to have no idea about the ethics of care towards my participants that I might need, particularly if they were younger or belonged to more vulnerable groups. I believe that an intervention of these sorts could be a particularly valuable contribution of the voices of those less often heard within the gallery space; were there to be future work done in this area, based on the findings of this thesis I would direct this work here.

While these craft-back projects would have given specific points of reflection, projects informed via visitor studies at these museums might have provided more information about the reception of the pedagogy in the space. After all, there is a gap between the curriculum as planned and the curriculum that is received and understood by learners, regardless of the learning setting. This could either have been visitors who were already in the space (Curran, 2019a; Tseliou, 2014) or by bringing visitors who would otherwise not have attended the museum to understand their interaction and reception of the spaces (Dawson, 2019). In the latter case, all my ethics of care concerns that I have raised with regard to interventions in the paragraph before remain here, and were the reasons that I did not run this type of study. In the former case of understanding those who are already attending the gallery, there is evidence of successful interventions to look at visitors attending the displays, particularly in the recent past. Photo-elicitation, for example, with the rise of use of photographic technology that allows looking back on the images the participant has taken immediately after the exhibition, has been used with families and young people with particular success (see, for example, Kirk & Buckingham, 2018; Judge, forthcoming). However, in the case of surveying visitors who were already there, existing research suggested it was very hard to get visitors to talk spontaneously about queer topics in public spaces. As Tseliou notes in their study of heteronormativity in exhibitions at Sudley House and Birmingham Museum and Art Gallery, it was both “almost impossible
to know who engaged” with the exhibition, and of those asked there were “negative responses...a few not being interested in being interviewed” (Tseliou, 2014, p.95). I expected, based on my pilot data collection about the gallery, this would be further compounded in these galleries by the fact most visitors are with small children.

While I am not appealing “to protect a mythical innocence we project onto children that talking about LGBTQ topics might somehow taint” (Hermann-Wilmarth & Law, 2018), it is clear that some parents are reluctant to engage with, or deliberately object to engaging with LGBTQ+-inclusive topics around younger children (Ring, 2015; Smith, 2006a). It would be particularly interesting to engage with these individuals through a critical literacy lens (Janks, 2000) and understand their construction of the gallery space through a gender and sexuality lens, but are most likely to be those who would be reluctant to engage in such discussion in front of their children. This brings me back to the criteria of bringing people to the gallery specially to discuss it, and with it the concerns I had about this mode of engagement.

I could have worked as Dodd et al. (2018) did, bringing in and working in collaboration with a group of researchers, disabled activists and campaigners to frame the questions posed to visitors to the exhibition, responses to which were then interpreted by researchers. However, I did not pursue this strategy because of limitations that made me concerned about exploitation of knowledge, time, and energies of campaigners with the potential of this thesis not changing practice. Firstly, I did not have any funding to pay a group of participants to work with me in development or as part of a focus group. Whilst some ethical discourses are around the practice of paying unrepresented participants (e.g. Head, 2006), there are a plurality of themes around this practice in the literature. Some argue that payment encourages participation (e.g. Edwards et al., 2002; Singer & Kulka, 2002), especially from those who “perhaps felt they might not have anything ‘useful’ to say, but had some interest in the project and the monetary ‘incentive’” (Head, 2006, p.337). Payment, particularly as part of a feminist tradition, is seen as an ethical marker –
to address/redress the uneven power relationships in research (e.g. Goodman et al., 2004; Thompson, 1996), especially as the researcher is likely to be compensated either through finance or “other external rewards” (Goodman et al., 2004, p.821). However, there is also the argument that payment might compromise free informed consent, especially among those earning low incomes, who “might feel coerced to participate if the level or ‘reward’ is too high to refuse” (Head, 2006, p.339). Suggestions that “[c]ompensation for participation in any research should be high enough to show respect for women’s time and expertise, but not so high that it might coerce women into participating when they would rather not” (Sullivan & Cain, 2004, p.615) could be difficult to navigate, especially working with individuals of multiple marginalisations. Even if ‘payment’ is not considered, less well documented is the payment of travel expenses, an important facet of a project that might ask research subjects to visit a gallery as part of the research. Unfortunately, even the reimbursement of travel expenses would have posed a financial challenge for me.

In market theory, Sandel (2003) argues that there should exist things that people can’t buy from positions of limiting coercion and corruption. Perhaps, if this study did not have financial backing to pay participants, one could offer the incentive of ‘changing’ the galleries or representation in these museums more generally in the future. However, to promise such changes to galleries is not presently within my scope. It would be a promise premised on the success of my research, my promotion of the research, and a reception of the work into professional practice in ways I cannot control. Work on *An ethical approach to interpreting disability and difference* (RCMG/Wellcome Collection., 2020) was shaped by “the many disabled artists and activists” involved in long-term research spanning collections across the UK, and ultimately changing the Wellcome Trust’s *Being Human Gallery* and producing guidelines for how other spaces could work on interpretation, grew out of being able to make this change.
Constructing my research project based on the considerations above, I elected to focus on the objects and gallery design as it exists in the 2018-20 period in London. Fowles (2016) has asserted that moving the claims and dialogues of anthropology from the human subjects of earlier eras to object subjects has created “quasi-human subjects” (Fowles, 2016, p.9) for investigation by detailing the ‘voice’ of objects that cannot speak for themselves. Rather than giving space for the voices of those who were previously the subjects of anthropology research, this shift reinscribed the power and authority of white, western scholars in being able to narrativize for objects that are silent. In my research focusing on the objects, design and texts of the gallery, and as a white, western scholar I am aware that I impose my existing narratives on these pieces. Whilst I will be taking an explicitly queer feminist approach, I should remain attentive to racialisation that may occur about the galleries and those included in them. Rather than working with subjects who may be excluded from the galleries that I have selected to work on, I have placed emphasis on understanding the inanimate galleries rather than the experiences of (non)visitors to those spaces. There are valuable benefits to this research, such as providing detailed critical insights about the construction of spaces that are for education of publics. However, this reliance on the galleries means that in developing the research I must be attentive to the problems of giving ‘voice’ to objects over and above people.

Further, to understand the context of the galleries that I am researching, I initially anticipated a combination of archive work and talking to present or past curators, as other scholars have done (e.g. Cassidy et al., 2016). However, these data have been limited by difficulty getting access to the people or documents that would facilitate this. I had greatest success getting both historic records and testimony from the curator at the Science Museum, where I already had connections. Whilst I was able to see the archival material on the development of the From the Beginning Gallery and talk to the curator of Royal Observatory Greenwich, I was unable to get more primary source material on these galleries, despite repeated attempts through the 2018-20 period. I also latterly came to see
this material as less urgent as I had supposed at the start (as detailed above) and have not utilised as much as was anticipated.

There are additional limitations I will highlight in brief. By using some autoethnographic data, I am aware that this critique may become personally motivated. However, as detailed above in my methodology, all queer feminist research should be acknowledged as being subjective and then dealt with as such, rather than assumed to present an objective commentary on the social world. My research could be argued to be limited by not having looked at the curatorial process (e.g. Macdonald, 2001) to understand the pedagogy of curators creating the gallery and the materials that were “tidied away along with the cleaning equipment, the early drafts of text and the artefacts for which no place could be found” (Macdonald, 2001, p.2) but rather the galleries as extant. I acknowledge this point; however, this research emphasises the importance of understanding what is present at the given time for visitors to the museums rather than the choices that were made previously about what would be there. My research is bounded, but perhaps also limited, by geography through using galleries that are all in one city for analysis. Scholars such as Jasanoff and Kim (2015) argue that is cross-cultural comparisons that elucidate information about imaginaries and how subject matters are thought of at a particular moment in time. The galleries have their origins over a time span of decades and this research will make visible some of these changes in imaginaries as well as pedagogical techniques over time.

Unlike many of the limitations detailed here which I was able to think critically about prior to conducting my research, there were a number of difficulties that arose during the research project that I had not foreseen. As much of the literature on museums exhibits is around the construction of temporary galleries, or retrospectives on galleries as they close, I was unprepared for ongoing change in the ‘permanent’ spaces. From my work as an Explainer in an interactive gallery used by hundreds of children daily, I was aware that interactives in the galleries I was studying would be in various states of functioning or not
functioning over the data collection period I spent at the galleries. I was, though, unprepared for the significant changes that happened in the galleries in the six months between my pilot visits to the galleries and my return visits for data collection. The space futures section of Exploring Spaces had been changed to house the Soyuz Capsule, newly returned to the museum after a tour of the UK; the videos at the Royal Observatory Greenwich had been changed from being something visitors could operate to select a video to running in a linear sequence on repeat, where watching the whole half an hour on loop was the only option. I have decided that I will mainly focus on the galleries as they were at the time of the data collection, because the emphasis of this research project is on understanding the galleries as they exist to the public at the time of writing; however, I will refer back to these only recently changed spaces that I had documented in the pilot data collection when the previous formulations of the gallery spaces may provide interesting counter-points.

3.3.4 Me as a researcher

As a queer feminist researcher, I acknowledge my limitations as a researcher in terms of my positionality and my responsibilities. I am limited as a researcher in being a white, highly educated, western woman. For instance, I was initially drawn to why parents saw absences of ‘famous’ white women scientists like Ada Lovelace or Marie Curie, but did not ever enquire about the whereabouts of women scientists of colour, such as Katherine Johnson, Madame CJ Walker, Mae Jemison or Raye Montague. However, within this interest was a narrow conception of how asking for, or looking for, ‘representation’ in a gallery could be done. It was constrained by hegemonic ideas of how to include narratives in the same ilk as ‘great men’ of science. By undertaking this research project, however, I hope to demonstrate that I as a researcher have become better aware of the limitations of my knowledge, and thus able to articulate (as I have at the end of my thesis) ways of thinking around them and exploring ways of improving my work. Indeed, even thinking that a museum is a worthwhile place to make the types of intervention I discuss in this
thesis is a result of my limited perspective as a highly educated researcher who was interested in museums to begin with – there are many other public domains that are more accessible to a range of publics in various ways. As a researcher who came from the physical sciences, I was also limited by my knowledge of social sciences at the start of my doctoral studies. I have utilised this research period to learn about academic queer and feminist concerns, and to think about what and how future research that I might be engaged with would look like.

Towards the end of my research project I have been talking about my research in the public domain more – at events, conferences and in workshops, in formal and informal settings. I often receive not insignificant push back (especially from white men both those who work in science and in museums) on the relevance of my work, why anyone would want to bring other voices to the museum, or what sexuality and gender even have to do with science anyway. I am, as a result of undertaking this research project, becoming more confident in articulating answers to these questions. As an illustrative example, following a presentation I made at a conference focused on the use of objects in the history of science, I was approached in the toilet by a senior member of a major museum who told me that my work was “cheap” as it addressed old galleries that were not emblematic of the current views of the institution. Speaking about such events chimes with Ladson-Billings’ encouragement of the importance of “naming one’s own reality” (Ladson-Billings, 1998, p.14) in order to understand the material outside of the hegemonic research piece. My initial conception of the ethics that I had developed thinking about the research project focused on who I would work with, how I would position the research, the care I would take with the research and how I would publish and talk about it. But I did not think about the ethics of care for myself (Lorde, 1988) when disseminating my research, about how I should or could look after myself, appreciating “the emotions and relational capabilities that enable morally concerned persons in actual interpersonal contexts understand what would be best” (Held, 2005, p.10). This instance also threw into relief for me times where I too may have placed an emotional, caring, response, above an ethic of care; or where
indeed I may have abandoned emotional care in favour of a rational sense of ethics and justice. To me, these are not distinct from the ethics that I described at the start now that I see them; however, I came across them through different interactions, and it has given me an appreciation of ethics of care situated differently in different places.

3.4 Summary

In this chapter I have explored my methodology and how this links to the approaches to epistemology, ontology, theoretical basis, and frameworks. I particularly drew attention to the difficulty of articulating a ‘queer feminist’ methodology based on the contingent and ephemeral understanding of queer:

This is not a simple task in an academy that increasingly embraces ‘queer’ contingencies while simultaneously requiring specific rules of rigour, clarity and truthfulness; all the while generating queer celebrities who supposedly ‘get it right’. (Browne & Nash, 2016, p.8)

I have then introduced the methods that I will be using as well as adaptations that I have had to make to allow them to better answer the questions that I have asked. Following this, I detailed the galleries that will be the data set for the research, and discussed limitations, difficulties, and alternative methods that I could have taken for this research.

At this point in the thesis I have introduced the foundational literature and methodology on which my research is based; I have articulated where my research questions have arisen, the gap which they are intended to fill in the existing academic literature, and the methods that I will be using to interrogate the data towards answers. In writing about how to take a feminist methodology into research, Chakravarty, Cook and Fanow (2012) ask “What should praxis embrace – solution or identification?” (Chakravarty et al., 2012, p.696). Inflecting this feminist position with queer theory, I would paraphrase these
options as “solutions or identifications” – understanding that there is no one solution possible through praxis. The two chapters that follow will explore identification of the narratives and imaginaries that exist in these case study galleries, and Chapter 7 will present the Queering the Science Museum tours as an exploration of a solution as well as discussing the limitations of such projects. Thus, this thesis will attempt to explore the ways queer feminist praxis can develop both the identification and suggestion of solutions in the context of science museums.
Chapter 4 People and/in Space

In a side display case in the Exploring Space gallery at the Science Museum is a cabinet of foods eaten on the International Space Station – a can of coke, tins to be opened, Extra gum, cereal cubes, chicken salad, sachets of Heinz ketchup, mayonnaise and some seasoned scrambled eggs. As relatable ‘everyday’ items that visitors to the galleries and astronauts alike will recognise, food is something that could open conversations about going to space. But whilst this food is often used to engage with the role of an astronaut – videos of them eating or drinking globs of water, questions about what ‘you’ would want to eat in space, talking about the culturally specific things that different astronauts request for food to take – there are many other ways that these objects could be contextualised for plural stories. For example, there could be a social history of how food on the space station has changed over time with the introduction of astronauts from all over the world, or the possibility of looking at foods from different space agencies to understand geographical plurality of types of meal eaten in space. Information about manufacture of the food could be a different discussion, including those who prepared, cooked, or trialled the food before it went to space. Profiled in local newspapers, but not in official archives or publicity materials, Black American women such as Julie Stewart and Sara Thompson were part of teams that planned and prepared meals for Apollo II astronauts, culinary workers who were written out of canonical histories of these projects (Chasten Long, 2019). Much like the Black computers of the Gemini programme, brought to light in Shetterly’s Hidden Figures (2016; Shetterly, 2016), knowledge and display of marginalised contributors to the space programmes who occupy pivotal, but overlooked, positions can open ideas about exercises of power around what narratives could be constructed around objects in museum collections.

Museum collections hold multitudes of artefacts, models, images, and maquettes. Some of these themselves are to do with people – images, objects used by or belonging to
individuals – ‘celebrated’ scientists, technologists, engineers, mathematicians or medics. However, in addition, alongside physical (and increasingly, digital) collections run collections of stories that may be brought into play to ‘bring objects to life’ – stories that are about the people using, developing, working alongside the ‘celebrated’ professionals. Situating artefacts in a network of social meanings, users and journeys both before and during their time in the collections could open many more ways of thinking about the identities on display. Seeing this constellation of options around the items that are on display also helps see the exercises of power that are made in these gallery spaces in the choices made around displays.

As explored in my literature review, this consideration of who is included and how they are included is valuable in thinking about how an audience of visitors has been conceptualised. I explored, in particular, the theories of social structures of identity and processes of self-verification. While existing theory might encourage us to think about these different ways of conceptualising identity as being distinct, a queerer approach to these identity categories would be to see them as mutual, engaged and co-constructed in the gallery space. Indeed, to think queerly for me is to challenge a fundamental of essentialist identity categories that presumes that they are able to be independently understood or articulated, instead, seeing them as constructionist categories that are enabled/disabled by the environment around them. Thus, the individual in relation to the setting and surrounding has the ability to make remarkable the ‘unmarked’ category or identity that is common and clear in these spaces (Davis 2007, McRuer & Wilkerson, 2003) and constructed as ’normal’ in the space. The construction of identity is fundamentally relational to the context; finding yourself in the galleries can be empowering (see for instance, Castle (1993) recounting of the experience of lesbians on encountering Vita Sackville West) and, through this, we can see how it is possible to instrumentalise “public history ... as a means of culturally understanding the present” (Oram, 2011).
Throughout my thesis I will be offering interpretations of the galleries informed by my queer feminist methodology. One strength of this methodology is the potential it has for generating provocative and challenging interpretations, interpretations that may be orthogonal to the expected, anticipated, or conventional understanding of the elements of the galleries that I present in this thesis. Rather than describing my interpretations alongside the hegemonic understandings of these elements, I interrupt, disruptively, the heteronormative thinking of the gallery curriculum and pedagogy (Sumara & Davis, 2002), and discuss only the interpretations informed by my methodology. This places queer feminist interpretations not as a secondary or reflective ‘other’ understanding in my thesis – rejecting a binary of arguments (Fausto-Sterling, 1993) – but rather as an argument that stands without needing to rely on merely subverting a hegemonic reading. As Manning argues:

Queer methodologies deconstruct truth claims, question dualistic ontology and queer straight lines. (Manning, 2009, p.1)

Rather than reading in relation to these dualisms, truth claims, or straight lines, the arguments presented here interrupt and develop pluralised understandings of the galleries. Indeed, in recognising this decision, I also draw attention to the fact that the interpretations presented here are likely to be one of multiple queer interpretations of these galleries, such is the pluralising nature of this methodology.

In this chapter I present and discuss identities that can be seen, and will demonstrate that the gallery space replicates and furthers many of the injustices seen elsewhere in science, and continues to isolate and exclude members of society who are already marginalised in STEMM and museum spaces. In particular, this chapter will explore the axes of gender and sexuality, as well as also briefly exploring and challenging notions of racialisation, ethnicity, nationality, (dis)ability and professional status. Firstly, I will address the way people across the galleries are named and presented. Then, I move to considering the ways
that the galleries play into discourses around femininity, domesticity and sexuality in their portrayal of people in the galleries. Finally, I will articulate how gendered roles go deeper than simply the portrayal of individuals and are embedded in the styles and narratives around science that are in the galleries with a focus on active participation in science and the idea of the individual, 'lone' scientist success.

4.1 Who is (not) named in the galleries?

Across the three galleries I have enumerated the names of people and/or images of people in display in my analysis. Where both the name and an image are present in the same location, I have counted only one of the two as standing for the individual. I will later return to consider the impact of some people being named and having an image in the gallery space, and the axes along which people are only present as a name with no image, or an image with no name associated and which identities these actions privilege within the gallery space. Counting in this way and understanding it in relation to the locations in the galleries, helps to begin to situate those who are in the gallery against those who are not, and will facilitate thinking about narratives embedded within the galleries.

Further to just understanding relative numbers of people and the use of their names, I coded description of the way that these people have been included. This coding of the modes of presentation in the gallery allows me to compare the instances by critically appreciating ways that the production of individuals and narratives in the galleries confirms or disrupts standard theorisation about media representation of scientists.

4.1.1 Who is where?

By gallery, the From the Beginning Gallery has the fewest people mentioned, and unlike all other galleries people are included by name only as citations for studies or images, not as points of interest themselves. (Table 5). The Weller Astronomy Galleries at the Royal
Observatory have 109 instances of people, unevenly distributed across the three different gallery rooms that the display is broken down into. While the Science Museum Gallery has substantially more people mentioned that in any other gallery, they too are unevenly distributed across the gallery space itself. By looking at the distribution it is clear that the sections in Exploring Space on histories of rocketry and life as an astronaut make up the bulk of the contribution to the material with almost no people featured in sections about what might be considered ‘planetary science research’ or the future of space science. In this way, the Exploring Gallery is similar to From the Beginning, both of which treat knowledge about planetary Outer Space as a-personal. In contrast, researchers and children asking them questions are centred through video in the Astronomy Questions gallery on ‘pure’ space science research, allowing the gallery both to bring in children as stand in for ‘visitors’ to the gallery in the video, and to highlight ‘expert’ scientists to be the faces of space science research being done. This change can be seen to run parallel to a changing understanding of the role of representation in the gallery over time, encouraging individual stories as points for visitors to relate to between the initial iteration of Exploring Space and From the Beginning and the Weller Astronomy Galleries.

<table>
<thead>
<tr>
<th>Museum</th>
<th>Gallery</th>
<th>Number of instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHM</td>
<td>FTB</td>
<td>3</td>
</tr>
<tr>
<td>RMG</td>
<td>AI</td>
<td>4</td>
</tr>
<tr>
<td>RMG</td>
<td>AE</td>
<td>13</td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>92</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>147</td>
</tr>
</tbody>
</table>

*Table 5: Number of people in each gallery of this study.*
4.1.1 Alone together?

While across Exploring Space and the Weller Astronomy Galleries terms such as “scientists” and “astronomers” are used to gesture towards collective works, there is little material that explicitly communicates to scale of collaborative work in space sciences that are on display across all three galleries; instead, most stories are centred on one person suggesting a mode of historicising science that favours celebrating the individual. Thus, collective terms (such as ‘scientists’, ‘astronomers’, ‘we’) are used to invoke the idea for the visitor of a collective practice and inclusion, but when explored in detail individuals are not situated within a network of other workers and are instead considered in isolation. The co-occurrence of names in the gallery text, or multiple people in an image together in galleries, is infrequent, limited to a couple of instances across all three case studies. This position of the isolated individual is a thread that emerges across this chapter, and I explore the ways that individualism is co-constructed with gendered representations, other marginalisations, and reification of particular types of (solitary) work within the space science fields. I draw attention to this feature at the beginning of this chapter, to see it unfold through the chapter in relation to the positioning of people in relation to science, to narrative construction, and to the ways in which active work in science is constructed within the galleries.

4.1.2 Champion

Both within and across the galleries there is variation in the ways that names of individuals are used. Many figures in the history of science were referred to only by their last name across the galleries: most notably and most often Einstein, Herschel, Galileo, Newton, Goddard, Verne, Oberth, and Gagarin. This pattern in naming reflects findings elsewhere on gendered references to STEMM professionals – where on average public media sources were over twice as likely to refer to male professional figures using their last name only (Atir and Ferguson, 2018). This gendered bias in the mode of referring to
STEMM professionals in the galleries has consequences for the perception of the importance of the named individual – Atir and Ferguson showed that members of the public inferred that scientists who were referred to by last name alone were 14% more deserving of a National Science Foundation career award than those referred to by both first and last name. Thus, these galleries continue to reinscribe extra value to white men of the western world by use of their last names to refer to them.

While in the vast majority of cases throughout the galleries both a first and last name are used to refer to an individual who might then later in the same or adjacent texts be referred to by only their last name, Helen Sharman (the first British astronaut) is named by both first and last name, and is then later in the same text referred to as ‘Helen’ [SM-ES-T19]. Sharman is the only person referred to by only a first name across all three galleries. This echoes research around the gendered power of language such that dominant individuals (by social class, racialisation, gender, age, occupational position) in society are more commonly referred to by the last names, and in turn are more likely to refer to those perceived to be subordinate by their first name – linguistically subordinating the latter by infantilising them using a familiar name rather than a formal title. Indeed, more than simply subordinating her through the use of her first name, Sharman is further ‘infantilised’ by needing “helpers” to get dressed into the space suit like a child, and having the life support system described as “umbilical interfaces” [SM-ES-T19].

In the display of Tim Peake’s space suit at the Manchester Museum of Science and Industry labels these connectors as “electrical and air connectors in the abdomen”. Whilst he is still listed as ‘Tim’ in the body text of the label (but not the title – where he is ‘Tim Peake’), I would argue that this is in line with the new ‘Science Capital’ approach that the Science Museum Group takes to exhibits, to create labels that make science relatable and accessible to the viewer (Science Museum Group, 2018), rather than an exercise in subordinating the individual. Contributing to my reading of the label is the language of
the text that has Peake as an active participant (“enabled him to communicate”), as well as a prepared survivor (“It would have kept him alive”), in line with the discussion around disaster used in displaying Peake covered elsewhere in this thesis. Furthermore, this same suit’s later display in the National Space Centre (at the time of writing it is on loan to their exhibit) refers only to “tubes on the suit”, a description that is also used for the other suit Sharman wore during her space flight, which is housed at the National Space Centre.

4.1.2 Not named, but in the galleries

There are some individuals who are included in these galleries, but without their names where the likeness of an individual has been used without any description of who they are. I include them in this section in, drawing on social construction of identities for individuals coming to the spaces and the queer destabilisation of a constructed ‘normal’, it is key to highlight who is partially in the space but not celebrated in the same way as other individuals. I have described the individual where their identity is unclear. In some instances, the person who is unnamed is known to me as a result of being a celebrated figure in space science, and in these cases I have included their name in Table 6 in brackets after their description. Access to this knowledge is limited by the cultural capital I have (Bourdieu, 1986) – and some of the people who are in these images may well be unknown to other visitors to the space.

<table>
<thead>
<tr>
<th>Museum</th>
<th>Gallery</th>
<th>Name</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>&quot;Chinese and Japanese astronomers&quot;</td>
<td>name, achievement</td>
</tr>
<tr>
<td>RMG</td>
<td>AE</td>
<td>&quot;crowds&quot; at Giggleswick</td>
<td>image</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>A German soldier with rocket</td>
<td>image</td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>Antarctic scientist</td>
<td>image</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in EVA</td>
<td>image</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit</td>
<td>image</td>
</tr>
<tr>
<td>Code</td>
<td>Type</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>--------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit model in full size diorama</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit model in full size diorama</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit [Mae Jemison] image</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit [science] image</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit [seismometer] image</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit [seismometer] image and model</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit [suit] image</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut in space suit [Yuri Gagarin] image</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut on ISS image</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>astronaut on Moon image</td>
<td></td>
</tr>
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<td>SM</td>
<td>ES</td>
<td>astronomer image</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AE</td>
<td>astronomers in Hawaii image</td>
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</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>Beagle 2 technicians (x2) image</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, black and white striped shirt video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, black shirt video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, light blue shirt video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, pink shirt video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, red and black striped shirt video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, red jumper video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, white shirt video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>child, yellow shirt w spots video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AE</td>
<td>man in mission control video</td>
<td></td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>narrator</td>
<td>video</td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>----------</td>
<td>-------</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>NASA rover technicians (x4)</td>
<td>image</td>
</tr>
<tr>
<td>RMG</td>
<td>AE</td>
<td>person standing on Ahnighito</td>
<td>image</td>
</tr>
<tr>
<td>RMG</td>
<td>AI</td>
<td>signer</td>
<td>video</td>
</tr>
<tr>
<td>RMG</td>
<td>AE</td>
<td>signer</td>
<td>video</td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>signer</td>
<td>video</td>
</tr>
<tr>
<td>RMG</td>
<td>AQ</td>
<td>signer</td>
<td>video</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>Skylab and Salyut astronauts</td>
<td>video</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>spacecraft support workers (x6)</td>
<td>image</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>worker for Hubble data</td>
<td>image</td>
</tr>
<tr>
<td>SM</td>
<td>ES</td>
<td>two astronauts [Hubble]</td>
<td>image</td>
</tr>
</tbody>
</table>

Table 6: Images or references to people in the galleries without names.

4.1.2.1 *Miss missing you*

Across the galleries, a number of the people who remain nameless are the technical workers – including those seen to be doing technical work who may not be technicians, such as those operating computers in mission control in the Astronomy Explores Gallery. In *The Invisible Technician* (1989), Shapin argues that either the technicians are rendered entirely invisible, and are simply not included in the narratives around the work that is
Figure 3: Mae Jemison (bottom) pictured in the Exploring Space Gallery (Image credit: E. S. Armstrong).
Figure 4: One of the BSL interpreters, shown on screen with Prof. Monica Grady’s introduction (Image credit: E.S. Armstrong).
being done to come to scientific knowledge, or, when they are included, they are described “the picture represents them as faceless and hence lacking personal identity” (Shapin, 1989, p.554).

The gallery depictions of these workers, as majority unnamed and therefore less knowable or relatable conforms to the same narratives that Shapin puts forward for the underdevelopment of the role and work of a technician. There is, across the galleries, variation in the depiction of these roles – from only seeing the backs of heads or clean suits in the lab to some individuals who are seen from the front but still unnamed. Perhaps this semi-transparent visibility should be considered a distinct category to the ‘invisible’ technicians of Shapin’s reconstruction of Boyle’s laboratory – in that they are in some way ‘valued’ but still constructed as less important than named theorists or engineers.

Mae Jemison, depicted unnamed in Exploring Space (see Figure 3, [SM-ES-C1]), alone in a round image of her in an orange flight suit, fits a media representation of Black women as “strong, single, and independent” (Reynolds, 1997, p.97), a trope that is a “fiction popularised by the media which has now filtered through our common sense discourse and influences …. academic discourse” (p.97). Most urgently, the demonstration of a single image of an unnamed woman, Jemison, in place of all Black women in the space science sphere, implies an essentialist approach to Black womanhood that understands all Black women as the same (Amos & Parmar, 1984; Reynolds, 1997).

It is such instances of “colourblindness (underpinned by racism) that make Black people (in)visible” (Maylor, 2009), thus creating a silence “on the subject of blackness and specifically representations of womanhood” (hooks, 1992, p.3) in STEMM galleries. Such action make it imperative to be critically reflexive and see the whiteness of the womanhood represented (hooks, 1996) in the galleries: the only experience of Black womanhood available in the gallery is invisibilised by displaying the image of Jemison.
without a name, and spoken through the patriarchal lens of the gallery itself (Mirza, 1997). This silence echoes the use of HeLa cells – taken from Henrietta Lacks, a Black woman - as the first human cells to ever be sent into orbit in 1964 to understand the effect of zero gravity on them (Skloot, 2010), which could perhaps open a site of discussion to racialised narratives lost in these hegemonic histories of science.

By contrast, in the Astronomy Questions Gallery, Maggie Aderin-Pocock [ROG-WAG-AQ-V3], a Black British space scientist, is one of the researchers included in the films, discussing her research. Incorporating her demonstrates the movement of voices of Black women from the “margins to centre stage … encourag[ing] critical reflexive thinking about gender and race, and it provid[es] a challenge to the normative discourse” (Reynolds, 2002, p.592) found in the rest of the galleries. However, Bhattacharyya (1998) argues that this type of action of introducing ‘new’ stories does not in itself counter the previous invisibility of Black women. I argue that elsewhere in these museums an ongoing, normalised and endemic racism across these physical spaces (Brah & Phoenix, 2004; Delgado, 1995; Essed, 1991; Gillbon, 2008) exemplifies this – including Black people in the exhibits but not, for example, in the curatorial or front facing staff, is not significantly changing the invisibility of Black women in these museums.

The final group of unnamed people in the galleries I address is the BSL signers in the Weller Astronomy Galleries. Providing signed interpretation of the material in the gallery provides accessibility to the material that is also both spoken and closed captioned (see Figure 4). While this provide access to d/Deaf visitors, through understanding the social model of disability (Oliver, 1976), it also opens a way into thinking critically about this inclusion. Whilst this has reframed the who is imagined as a visitor to the gallery space (Dawson & Jensen, 2011; Falk & Dierking, 2000), it has not developed how they might find themselves represented.
Having BSL interpreters as the mode of engagement for members of d/Deaf communities belies a complex relationship between these communities and the people who support their access needs. Research on the position of interpreters has addressed the implications of unequal professional status and power of knowledge claims in the workplace through interpreted interaction in white collar jobs (e.g. O’Brien & Emery, 2013). Research on interpretation as interaction demonstrates that the understanding of interpreters as non-participating, or a non-person conduit for information, does not, and cannot, always hold true (Wadensjö, 1998). Instead, researchers such as Tipton (2008) and Young et al. (2019) explore the impact of an interpreter in shaping the voice of an actor for the receiver (although often from the perspective of the receiver being a hearing person), and Diriker (2004) considers the interpreter’s negotiations of constructing multiple speakers’ positions during translation for different speakers and participants in an event, as is the case in this gallery. Hearing visitors do not have to experience these problems – none of the signers are translating from a d/Deaf professional; instead these problems sit with d/Deaf visitors.

Thus, in the content of these space science displays, across all galleries in this thesis, disabled STEM professionals are almost entirely invisible, as is often the case in other galleries (Dodd et al., 2010; RCMG/Wellcome, 2019). Contrast this representation with that in the Science History Institute’s Science & Disability ExhibitLab that “illuminated new ways of engaging with our collection through the intersection of space science and disability” (Martucci, 2020), for example through thinking about the materiality of spacesuits and the bodies they implied. An emphasis in the project was on both access (including Braille interpretation, and signed workshops) as well as inclusions of narratives that disrupted ableist presentations of science (see also Shew, 2020). Even within these pluralising accounts and explorations of disabled scientists, whiteness is emphasised in the feminist work (Mirza, 1997), and narratives and imaginaries of disabled people of colour remain absent (Kuppan, 2018).
4.1.3 On the map

In addition to the above lists (Table 6) I considered these individuals in local maps of the gallery spaces to explore some elements of the naming distributions that are related to spatial variation to help understand identities that are encouraged to be formed by visitors to the gallery space. Mindful of Haraway’s critique of the ‘god trick’ (1988) and a perceived view from nowhere, I created six figures in doing my analysis, the three galleries from a plan view of the space (in Appendix (C)), to illustrate distributions of individuals; and the three galleries from the entranceways to the spaces, to give ideas about who and what is visible from the perspective of a person entering that space. In discussions that follow, led by insights from situated practice, I will be thinking not only about how these individuals are presented but also where and in relation to what.

In the From the Beginning Gallery, there are few instances of people who are named. Where they are included it is as a credit for research or an image, rather than a story about a researcher or participant. This gallery can be seen as an appeal to an ‘historical’ mode of thinking about science (Cleland, 2002), where the discourse of the field passively explains the phenomena of distant locations, making appeal to results without needing to know who (or what) is doing the work that gives the results in the gallery. The gallery gives a static overview, presenting the knowledge as being without genesis and without change but rather existing in the world.

By contrast, the Exploring Space Gallery shows a gallery layout divided into five different blocks, based on the distribution of people in the gallery space. Clearly, there are two large localisations of people narratives, in the section on astronauts and people in space, and in section on theorists of rocketry development. There are significantly fewer individuals in the other two sections, only a handful between them, marked in the section on planetary science, and the section that I shall characterise as the present and future of space travel.
The final section of the gallery on the Skylark rocket is a temporary part of the gallery, and thus will not be considered in this thesis.

Within the Exploring Space Gallery there is a priority for particular types of stories: individuals are people in space or Earth-based theorists developing rockets going into space. As these are smaller subgroups of all people who work within space science, it appears that there may be a limited selection of stories that can be told about these groups – an assumption which will be interrogated and challenged through the rest of the chapter. However, significantly, there are very few stories in other parts of the gallery. This has a dual function in the narrative development. It constructs these sections of space science research as not being something that is active or available for participation, but instead as apolitical and natural knowledge. It further obscures the possibility of the diverse range of individuals who work in planetary science or the present and future of space science as being people whom visitors see themselves reflected in and can develop self-verification alongside. This is valuable to reflect on in relation to the second question of my thesis:

By being attentive to the presence of the curated gallery space, what is absent in the gallery?

Here, the absence of narratives about researchers on Earth who develop and create knowledge about space science constructs them as being less valuable or worthy of interest to visiting members of the public. Compared to the ‘prestigious’ and named theorists in the History of Rocketry, and Astronauts, these sections on knowledge about planets and development of the space craft that are sent into Outer Space are silent on who is doing the work. This in turn constructs for the audience the idea that this is less valued or valuable work done by people than those that have narratives alongside. Understanding that the knowledge in all these domains is constructed, subject to interpretation, and part of an ongoing, developing canon of understanding about the
universe we live in, might be perceived as a challenge to the ways that these sections display an objectivity and neutrality about the natural phenomena studied.

This paucity of women in the displays in early missions, space science work or as astronauts fits with other quantitative studies of space science mission gender distribution. Rathbun’s investigation showed that women were consistently underrepresented in mission teams – although their research only used lists of “principal investigators (PIs) and co-investigators and did not include project management teams, engineers, graduate students, postdocs, or team affiliates” (Rathbun, 2017, p.1). This was underrepresentation both in absolute terms, and also against the already unequal representation within the space science field to begin with, where in 2013, women reportedly still made up less than 30% of those working in the field (Rathbun, 2017, p.2). The study also acknowledges that within this sample, “white women are over-represented compared to women of colour”, something which is certainly true in the examples for broader inclusion that I mentioned above (and is still the case in the research three years later of Rathburn et al., 2020). As a counterpoint, and to underscore the urgency of being able to include more recent missions, the 2020 announcement of the Discovery Class missions for NASA had two selected missions run by women, and a third where the woman who had led the mission as principal investigator had ceded formal responsibility for the mission to be a senior member of NASA decision making team (NASA, 2020). Being able to include more recent contemporary missions such as these might go some way to demonstrating a changing tide in the roles women and non-binary individuals occupy in the space science research field.

Drawing a comparison between the Exploring Space and the From the Beginning galleries we see a similar lack of agential human working within the scope of planetary science. In From the Beginning not only are there no names (and thus no people) attached to the work that is being done in these research fields to understand planetary science, but there is not even commensurate reference to research bodies (e.g. ESA / NASA) from where
the images, facts and diagrams that make up the bulk of the gallery in the From the
Beginning planetary section, suggesting that this knowledge instead appears to exist a
priori in the world rather than being constructed and known by international research
organisations as is the case in the Exploring Space.

However, the Weller Astronomy Galleries present a very different view of agency in
developing knowledge. As a case study I will to contrast the presentation of images of the
Sun. In Exploring Space images of the Sun in different wavelengths are one of the first
blocks of pictures and text seen by visitors on entering the gallery from the main entrance
of the museum, printed on a board on the right-hand side of the gallery. Visitors are
presented with some explanation about how to read the images as data about the Sun
from the instrument, SOHO (Solar & Heliospheric Observatory); for example:

This image from SOHO’s extreme-ultraviolet imaging telescope shows a loop or
prominence, of solar plasma – 30 times the size of the Earth. [SM-ES-T5]

The instrument is mentioned in passing – there is some explanation elsewhere about
SOHO but without developing an idea about what it is or what the abbreviation stands for
– as is the wavelength the images has been taken at. A technical term (“prominence”) is
introduced, and an element of relating it to the Earth is made. From observing visitors
interact with this image, I note that they struggle to comprehend what it represents. While
the image associated with the caption is coloured yellows and red, and younger visitors
recognise it as the Sun, it is often lost that the other images (in false-colour greens and
purples) are also the Sun unless there is someone in the group who is able to help the
knowing in this context. While the caption describes it as an “image”, suggesting it is
naturalised rather than constructed, the text does early on say that it is “made” (but
without human agency) and that “The false-colour images help our eyes to distinguish
different features”, positioning the visitor as someone making knowledge in the context.
By contrast, similar images are explored in Astronomy Explores under the title on the gallery wall “More than meets your eye?”. Here, however, the digital interactive allows visitors to manipulate and engage with images from different parts of the electromagnetic spectrum, and create colour composite images. While I observed the gallery, I noted that playing with spectral images on this digital interactive was interesting to young people, especially given the brightly coloured changing images. There is also considerably more detail about how data are used by “astronomers” to “convert to make an image. These ‘false-colour’ images help us to picture the universe in other wavelengths” [RMG-WAG-AE-T6]. Here, data are collected and then interpreted by “astronomers” and these are then seen by “us”, suggesting a process in developing images that is mediated by people. However, even in this explanation the “astronomers” are still abstracted entities.

Across the Weller Astronomy Galleries the distribution of people is heavily weighted towards the Astronomy Questions gallery, where videos playing on loops feature young people asking questions and experts answering them using their research, as well as timelines of important events, observations and ideas in the history of astronomy, and their initiators. Additionally, there are some people mentioned and pictured in Astronomy Explores, linking the idea that research that is creating the knowledge discussed there is being done by people from across the world and history.

4.1.4 Fame < infamy

What might be seen as a ‘feminist turn’ in the history of space science curation is seen in a clear over time in the gallery case studies here, and in some other examples which I will touch on briefly. In the Exploring Space gallery, the oldest of the three, images of women or non-binary people are scarce. Only the Queen, Helen Sharman and Lisa Ruffa are mentioned by name with Mae Jemison pictured but not named in the data collected in 2020. While there are other images of technicians and astronauts that may include women or non-binary individuals, there is not enough information available in the
galleries, in my conversations with the curator or in the archives to know who these people are for certain. The later Weller Astronomy Galleries include more women across a range of locations, as well as contemporary researchers in the Astronomy Questions Gallery (see Table 7; with genders as identified in their own public online profiles in 2020) – with a distribution that skews to men being more likely to be professors:

<table>
<thead>
<tr>
<th>Gender</th>
<th>“Dr”</th>
<th>“Prof.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Women</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Non-binary/GNC</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Table 7: Number of people in video broken down by gender and academic rank.*

Read in line with my earlier argument about the attribution of expertise to those with last names only and the correlation of this with men in the galleries in this case study, the positioning of expertise as being masculine is confirmed in this distribution.

It should be noted that temporary exhibitions such as ‘The Moon’ (National Maritime Museum), ‘The Sun’ and ‘Cosmonauts’ (both at the Science Museum) have had a larger range of identities represented. More senior women are included as scientists. More historic women are included, such as Cecilia Payne-Gaposchkin as a proposer of the Sun’s composition of hydrogen and helium (The Sun, 2018), and Mary Blagg as lunar cartographer (The Moon, 2019). These temporary exhibitions that have taken place during the time I have been writing my thesis have contained more counter-hegemonic narratives, which can be read against a construction of unilateral progress and hegemonic masculinity.

Additionally, in the Exploring Space gallery has a section that changes display on a semi-regular basis in the back on the right-hand side as the gallery. During 2019-2020 it hosts
'Skylark: Britain’s Pioneering Space Rocket’, but has previously had ‘Valentina Tereshkova: First Woman in Space’ (16 March – 16 September 2017); and in the back of the Science Museum in the Wellcome Wing, the BepiColombo Engineering Model has been in residence since August 2018 to the time of writing. These exhibits have highlighted some of the women who worked on the missions. At the Royal Observatory, newer content in the ticketed gallery “Observatory Life: At Home with the Astronomers Royal” and the free Altazimuth Pavilion, which details the work of Annie Scott Dill Maunder (nee Russell) as a ‘Lady Computer’ analysing sunspots and later wife to the Astronomer Royal Edward Walter Maunder (Devoy, 2019), also provide alternative, albeit heteronormative, narratives.

Theorists have suggested that the temporary exhibition offers something different to the permanent exhibition:

> temporary shows have been licensed to defy expectations precisely because they are that: short-lived. They are likely to induce less anxiety about whether they can stand the test of extended time (Arnold, 2016, §2)

and that it is the ‘temporary’ nature of the material that allows it to challenge hegemonic narratives around, for example, gender, ethnicity, ability, geographical location or class. While Macdonald has argued that part of the exhibition making act is to claim “legitimacy through memory inscribed as heritage”, creating a “more multivocal public sphere … incorporating at least some such voices into the mainstream” (Macdonald, 2009), there is perhaps an element of experimentation to find which voices might be ‘appropriate’ for the inclusion in these permanent galleries through these shorter exhibitions. I acknowledge the oft-raised concern that larger galleries are more expensive and involve a longer development time, and wish to counter this by directing the small changes in the Exploring Space gallery that have been ongoing between its opening in 1986 and this
thesis in 2020, which demonstrate that there are edits and developments within the galleries ongoing, but that they ‘fit’ the narrative tone of the existing gallery.

4.2 Narrative constructions around ‘gendered’ roles

It is not unusual as a doctoral student undertaking fieldwork to be asked what I’m studying. While I was collecting pilot and main phase data from these galleries in the hot summer months of 2019, I was asked a number of times in each of the three galleries what I was doing there – a young adult without any apparent minors as charges, holding notebooks and taking pictures of the gallery setting. Discussing my work on sexuality and gender in the context of space science galleries I got a range of responses: “Sex has nothing to do with space science” or, from one person more knowledgeable in queer scientists, “Well, the only LGBTQ+ astronaut is Sally Ride, so what, we should just include her in all galleries for representation?” However, the heart of this issue is deeper. If we only see gender and sexuality as categories of identity that can be thought to be expanded on against professional roles of people who are already included in the gallery spaces, in the instance above for example, astronauts, this artificially encourages us to limit the ideas of who would be appropriate in that space. This section will focus on some pertinent constructions of narratives within the gallery spaces. Through these comparisons I will demonstrate particular framings of normative identity, exploring the constructions comparatively between the galleries.

4.2.1 Femininity, infantilisation, and care-giving

Exploring Space has a space suit of Helen Sharman, the first British national in space – the naming of whom I have explored earlier in this chapter. Flown on a privately sponsored flight with Russian collaborators, chemist Sharman flew to the Mir space station as part of Project Juno in 1991 alongside two other Russian cosmonauts on board the Soyuz TM-
12 (Harvey, 2000). The purchase of the suit by the Science Museum was supported by the Heritage Lottery Fund (with an accession date of 2006 in the object number) and within the Exploring Space it is the only full, flown space suit on display (SM-ES-A32). There are two other items in the cabinet with Sharman’s suit, a space suit glove (worn by Yuri V Romenko, SM-EX-A33) and an underlayer for RAF pilots (SM-ES-A34). Additionally, close by to the display section of the gallery, and visible from the panel where Sharman’s suit is, there are also replica model Apollo era space suits, posed as if walking in their simulated lunar diorama, out on the gallery floor. Sharman’s suit (Figure 5) hangs oddly in the gallery space. It perhaps appears that the shoulders are too high, the helmet rocked forwards, the arms limp by the sides of the suit. Especially compared to the nearby Apollo suits, active in the act of ‘walking on the moon’ in the Exploring Space gallery, arms slightly raised, legs one in front of the other, Sharman’s suit is displayed in a particularly passive manner. Even compared to the water-cooled flight suit on the left of the display, the Sokol-K space suit seems to be draped in the lower light of the cabinet.

There is an inherent tension in making this point. Space suits are not designed to last, preserved in museum collections. Contrasting the display of this real artefact with the positioning of the model suits out on the gallery floor is rife with incommensurate comparatives – this historic item might have conservations needs that mean it must be positioned in this way. However, if this is a concern, there are an alternative possible display of this suit that positions it in relation to Sharman, or any of the work she did on the Mir space station, or with photographs of her in the space that present her in an active mode to counter and balance the passive arrangement perhaps needed for the preservation of the suit, against the active mode of display of the Apollo astronauts. The display label of the adjacent flight suit provides a gesture towards political, nationalist tensions that may have implicitly directed this choice:
NASA drew on this RAF experience when designing their own liquid-cooled garments that astronauts wore under their Outer Spacesuits while walking on the Moon. [SM-ES-T19]
Figure 5. Helen Sharman’s suit, displayed in Exploring Space at the Science Museum (July 2019). (Image credit: E. S. Armstrong).
There is an appeal throughout the Exploring Space gallery to the UK as a genesis of many innovations that go on to be essential to the NASA space programmes (which I detail further in subsequent chapters) from Apollo through to the contemporary period. Sharman’s suit, and indeed her flight itself, are Russian. Aligning the rest of the gallery strongly with the USA space programme makes it, perhaps, more difficult to celebrate Russian innovation and, along with it, Sharman’s flight to the Russian space station.

Sharman’s suit is one of the few objects across all three case study galleries that are tied to women or to non-binary people. The explicit inclusion of most others comes through images and descriptions of their works. For example, in the Living in Space section of Exploring Space, other than Sharman there is only Lisa Ruffa, shown working on a project around cultivating dwarf wheat as a crop to grow in the confines of the space station (see Figure 6). Pictured on Earth and not under microgravity, and identified as “Research technician ... at the Kennedy Space Centre” [SM-EX-T22], Ruffa is at odds with the rest of the people in the section that implicitly focuses on astronauts. There are no other technicians, people training the astronauts, nor helping to prepare for their flights. Ruffa is instead surrounded by astronaut men in space who are conducting space walks, sleeping, exercising and reflecting on their work in space. While Sharman is passive, voiceless and infantilised through the caption on the suit, Ruffa is relegated to be the only person preparing the food, or related to foods in the gallery.

Food and drink are essential components of space flight, often subjects of comic anecdotes about astronauts who didn’t like the culinary offerings of those organising their space flight including Tim Peake taking Yorkshire tea (e.g. *Tim Peake Special Edition Tea* at the National Space Centre, UK) or Samantha Cristoforetti drinking Lavazza coffee from the ISSpresso machine (Povoledo, 2015). There is a large selection of food on display adjacent to Ruffa’s image, that I described at the start of this chapter, but no other commentary from other individuals about food in the display. Historically, food (and by extension cooking) has been ‘women’s work’ (Fürst, 1997) – a task falling to
women within a household. More than this, food is not simply tied to women, but to femininity and the acts and being of the feminine – to fail at food, Cairns and Johnston argue, “also means failing at femininity” (Cairns & Johnston, 2015, p.vii). As such, while some post-feminist movements that maintain that food is not closely associated with femininity or women, the choice of a woman – and a ‘technician’ rather than (as elsewhere in this section) astronauts – harks back to the idea of woman as the natural, nurturing care-giver and sustenance provider. Without developing any alternative narratives, the pedagogical choice of linking food, femininity and providing for astronaut men together in this section suggests particular roles for women and girls who visit the gallery.
Eating and drinking

On Earth we can eat many types of food and cook them in lots of different ways. In space, we don’t have much choice. Space food must be light in weight, not take up too much room and remain edible for a long time – there are no refrigerators on spacecraft. Astronauts in Earth orbit can receive supplies from Earth every few weeks. Any crews that go to Mars will have to take provisions for up to three years with them and also grow much of their food themselves. If you went to Mars, what food would you least like to leave at home?

Figure 6: Lisa Ruffa, as featured in the Exploring Space Gallery at the Science Museum (Summer 2019). (Image credit: E. S. Armstrong).
Moreover, while other researchers have demonstrated the roles of women of colour in producing food for the American space programmes (for example, Chasten Long, 2019), this image centres on the white woman. Theorists elsewhere have rationalised different relationships between femininity and food, and how racialised such depictions of these relationships are. Igenoza (2017) has been explicit about how whiteness in food behaviours centres on dieting or restrictions around food, and that the presence of whiteness often also dictates a normalised and ‘safe’ type of food being eaten. Thus, this image could be read in critical comparison to racialised food shaming of consuming ethnic food that continues to take place within communal meals and popular media depictions of eating (e.g. ashiaray, 2019). By positioning this as a white woman making the food, there is a link to the food in the adjacent display (coke, chicken salad, cereal cubes, macaroni and cheese (SM-ES-A36)) as being ‘normal’ and ‘acceptable’ and non-‘yuk’ food stuffs for eating in space. This is in contrast to evidence that Chinese (宋薇, 2016; CNN, 2003), Japanese (JAXA, 2014) and Indian (The Indian Express, 2020) space agencies, for example, provide their astronauts with familiar foods from China, Japan and India respectively – as well as seasonal specials for their cultural holidays. Although some of these human space flight programmes are more recent, Russian space food has existed for as long as US space food and includes items such as Jellied Beef Tongue or Riga bread (Smithsonian, 2010); the exclusive display of US space food perhaps speaks to a bias in collecting, and an ‘othering’ of non-American space programmes seen elsewhere in the gallery too.

Indeed, NASA, in publicising this dwarf wheat in space experiment from which the photo of Ruffa is drawn, links the project directly with the sanitised Thanksgiving story of pioneers and Powhatans exchanging food, including specifically the corn that grew in the Americas as a link to the American future in space pioneering (NASA, 2007). The publicity performs a well-rehearsed erasure of genocide and the treatment of Indigenous peoples of North America around the relationship of settlers and Indigenous peoples, replacing it with narratives about friendship and helping:
The settlers established more friendly relations with the Virginia Indians who shared their knowledge about food, water and shelter. (NASA, 2007, §2)

Perhaps it is also fitting, given the way the gallery elsewhere draws on Star Trek, that this image also draws on another space trope: the ‘interstellar stewardess’ exemplified by the USS Enterprise, crew member Janice Rand. As a white feminine character, based on images of stewardesses of the American jet age, we see (echoed in Ruffa’s image) her position:

in a service role, bringing [Captin Kirk] tapes to view but also beverages to drink and food to eat. In fact in the first episode filmed, “The Corbomite Maneuver,” Rand’s initial appearance has her carrying a tray of food, which is also how she makes her debut in the first episode aired, “The Man Trap.” (Vettel-Becker, 2014, pp.152-3)

Subservient to her male leaders, positioned as doing the mundane work of the day-to-day tasks such as cooking or waiting, the ‘interstellar stewardess’ exemplified by Lisa Ruffa confirms Pearson et al.’s thesis that although the technology and science may change, gender roles of the imagined space future echo and re-enact those of the past (Pearson et al., 2008).

Employed in a similar way, although possibly to a different end, “Miss French” (Figure 7, [ROG-WAG-AE-T4]), a computer at the Royal Greenwich Observatory, is shown as part of an exhibit about computational astronomy. Until the recent past the fact that “the job of the programmer, perceived in recent years as masculine work, originated as feminized clerical labour” had been “rendered invisible” in computer histories (Light, 1999, p.455). Revivals and rewriting of these histories have culminated in texts such as Hidden Figures (Shetterly, 2016), and The Glass Universe (Sobel, 2016); and the inclusion of Miss French
Early modelling

Long before electronics, the Royal Observatory at Greenwich used ‘computers’. This was the name given to the teams of men and women who carried out the complicated mathematical calculations for the astronomers. The calculations helped predict the future positions of stars and planets, essential information for astronomy and navigation.

Figure 7: Miss French in the Astronomy Explores Gallery, Royal Observatory Greenwich, Summer 2019 (Image credit: E. S. Armstrong).
in this interactive focused on the role of computational modelling in contemporary space science and throws light onto these roles.

However, as Light describes, during the Second World War (occurring during the time Miss French is cited as working at Greenwich: “1930-1943” [RMG-WAG-T4]), despite these computational roles previously being occupied by men, “popular accounts portrayed civilian jobs for women as appropriately feminine, “domestic” work for the nation” (Light, 1999, p.461). While Light focuses on the US context, other scholars, including Croarken (2003), and Parolini (2015) who write on the British context, have noted similar gendered occupational divisions. Indeed, elsewhere at the Royal Observatory discussions about “women’s roles” are on display, including Annie Scott Dill Russel’s role as a “lady computer” in the 1890s in the Azimuthal Observatory and the families of the Astronomers Royal in “Observatory Life”. Devoy continues this exploration online, with extensive blog posts for Women’s History Months about these and other women too (e.g. Devoy, 2019). Much like the feminisation of cooking and domestic work in Exploring Space, this inclusion perhaps reinscribes women’s ‘proper’ position in the Observatory. Although the caption mentions “teams of men and women” [RMG-WAG-T4] working as computers, there are no images either in this gallery or online of the men who did the computing. Moreover, the direct link from this image to the caption of the application of contemporary computation of the “Millennium Computer Simulation … [running] for a month on a supercomputer to create 25 thousand gigabytes of data” [RMG-WAG-I2] provides no alternative vision of gendered agency in creating or executing the project, and thus instead links the woman with the machine, furthering an interchangeability and objectification of women that Light documents in the research groups in American Universities (Light, 1999).

Flicker (2003) suggests that one of six popular representations of women in STEMM films (extended, in this instance, to media more generally) is as “the daughter or assistant” (p.310), someone who is “indeed scientifically qualified” but who is “anchored in a social
relationship to a male scientist” as “translator for society ... a type of bridge between rationality and emotion” (p.314). In the examples I have given above, I argue the same construction of femininity and womanhood is being made. It is not in itself detrimental to show this role; but to having few or no alternative examples of what women could do in the gallery limits the pluralising work that is being done. In the case of the Weller Astronomy Gallery, Astronomy Questions has a number of scientists interviewed, and the following section explores their representation further in contrast to the work on these three women (Sharman, Ruffa and French). Finally, the images of these two technicians, or ‘workers’, Ruffa and French, in the galleries share a visual element of being depicted not addressing the camera. Drawing on theories of visual semiotics (van Kress & Leewen, 2006) as well as spatial situated practices (Haraway, 1988; Rendell, 2006) I argue this reinforces both the secondary nature of the woman researcher and plays into Shapin’s arguments, directing the viewer to look at the object that is being manipulated rather than the person doing the action. Thus, positioning women in these roles plays into two separate narratives about how technicians/technical workers are made (in)visible, and additionally into stereotypes about the role of women in STEMM.

Despite having a broadly historical focus to show a long history of astronomy, I believe that it would have been possible to include women’s involvement elsewhere in the Astronomy Explores gallery such that it wasn’t that the only named woman was a ‘computer’, celebrating a history of involvement of multiple genders in the research. Elizabeth Brown, for instance, an astronomer who focused on solar eclipses and sunspots, travelled extensively around the world for her observations and might have provided an alternative narrative in the transit section of the gallery (Kidwell, 1984); women from around the then-British Empire were involved in Observatories in Madras, Cape Town, Hong Kong, and Sydney (Kidwell, 1984), often situated as part of networks of knowledge linked with the Observatories at Greenwich, Kew, and the University College Observatory, all in London (Mcaleer, 2013). Similar work has been done to cover the making of knowledge in the botanical gardens of various empires (see, for example,
Baber, 2016; Barnard, 2016) – where some of the botanical gardens were co-located with colonial observatories (e.g. Keenan, 1991), itself bears into the ways exhibits and narratives around gender and colonialism in plants and cultivation are constructed in museums such as London’s Garden Museum (2019). These still allow access to knowledge about a reasonably select group of white, affluent, educated women. As Fara argues, these women were often exceptional in so much as they had access to wealth and connections that allowed them to do this work, recounting a history that instead centres the women’s networked importance rather than individual skill (Fara, 2018). Recovering other histories, around workers at the Observatory, people who worked on overseas observatories or in guiding and safeguarding overseas astronomical expeditions might allow greater pluralisation of the historical record. In any case, the Astronomy Explores Gallery doesn’t have an exclusively historical view – a section on space craft from the 1970s onwards culminates with the Beagle 2 Mars Lander (2003). I refer back to the argument made in recent surveys of the field that physical sciences are becoming more diverse with time earlier and suggest that greater emphasis on these more recent missions might also allow access to more plural narratives.

4.2.2 Don’t you know who I think I am?

This effort to represent a wider range of people in discussions about contemporary space science can be seen in the Astronomy Questions Gallery, with interviews with contemporary scientists answering questions (see Table 8). To reiterate, I have taken genders from their online presence rather than assigning them myself and use the titles the researchers are given in the data collected (since then, some have changed their honorary titles). I represent the data on the titles of individuals interviewed to reiterate a skew in the presentation of ‘expertise’ in the display (excluding the two narrators, both unnamed but one of whom is now Professor, then Doctor, Lucie Green).
<table>
<thead>
<tr>
<th>Gender</th>
<th>No Title</th>
<th>“Dr”</th>
<th>“Prof.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>1</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Women</td>
<td>0</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Non-binary</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Table 8: Genders of scientists in Astronomy Questions Videos.*

While in total there are fewer women, they, on average say more each than each of the men interviewed for the videos (W:428; M:319). However, this is skewed as there is a far greater disparity in the number of words spoken by those marked as ‘Professor’ (i.e. Senior in their career) to those more junior (Dr: 488, Professor: 270). These data can be seen in Table 9.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average for Women</td>
<td>428</td>
</tr>
<tr>
<td>Average for Men</td>
<td>319</td>
</tr>
<tr>
<td>Average Dr</td>
<td>488</td>
</tr>
<tr>
<td>Average Prof.</td>
<td>270</td>
</tr>
</tbody>
</table>

*Table 9: Averages of numbers of words spoken by gender and by honorary title given in the videos.*

In their 2010 research, Chimba and Kitzinger make the case that “men appear to convey an aura of “gravitas” but women appear whenever the science is being made “accessible” or “sexy”” (Chimba & Kitzinger, 2010, p.622). Although their research was done on scientists in the newsprint media, I would argue that the same construction is occurring here – the professors (skewing significantly male, white) are used to evidence the importance of the work, but earlier career women are being used to make the work accessible through greater explanation of the information.
Figure 8: Number of words spoken by individual experts in the film in Astronomy Questions, Royal Observatory Greenwich, Summer 2019. Green indicates someone who identifies as a woman in public profiles, blue is someone who identifies as a man, and the two yellow bars are the narrators of the videos. Titles are taken from the video (even though some have subsequently changed), with the exception of Green, whom is unnamed by I recognise by sight.

Not all of the interviewees related the work that they are talking about to their own work – allowing the same passive construction of knowledge in relation to “we” (an implied community of scientists and astronomers) that happens in the Exploring Space gallery but falling short of the passive, inactive construction of impersonal knowledge in From the Beginning. However, men interviewed in these snapshots of science are perhaps more likely to describe their own work – six out of the twelve talked about their work, whereas only three of the eight featured women did. More importantly, the semantics used are differ too along gendered lines too (See Table 10 for full details). Women interviewed talk more about the ‘work’ of science, using active verbs for research tasks (“to map”, “solving”, “I have been doing”, “I use”, “I have been carrying out”), whereas men talk
about the outcomes and success (e.g. “We found from my research that this is possible”, “I discovered”). The only woman not to follow this pattern is Dr Kathy Romer, talking about an outcome of her research demonstrating that “I [Romer] find these clusters of galaxies using X-ray telescopes”.

<table>
<thead>
<tr>
<th>Scientist</th>
<th>Quotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR LEWIS</td>
<td>“Mars is our next-door neighbour planet and many Astrobiologists like myself ...”</td>
</tr>
<tr>
<td>DARTNELL</td>
<td></td>
</tr>
<tr>
<td>DR JAMES DALE</td>
<td>“In my research on stellar collusions, we are trying to answer a very simple question.”</td>
</tr>
<tr>
<td></td>
<td>“Another question we looked at in my research was whether you can take / An elderly massive star, which has used up nearly all the hydrogen fuel in its core / And is therefore about to die, and rejuvenate it”</td>
</tr>
<tr>
<td></td>
<td>“We found from my research that this is possible”</td>
</tr>
<tr>
<td>PROF. MIKE EDMUNDS</td>
<td>“My own view would be that there is really not enough dust”</td>
</tr>
<tr>
<td>PROF. GERRY GILMORE</td>
<td>“This is a galaxy that I discovered with a student about ten years ago.”</td>
</tr>
<tr>
<td>DR BRIAN COX</td>
<td>“I work on a giant 27-kilometre long machine called the Large Hadron Collider”</td>
</tr>
<tr>
<td>DR DAVID BACON</td>
<td>“I am interested in trying to test those ways of changing Einstein’s theory”</td>
</tr>
<tr>
<td></td>
<td>“The way I do that is to measure the banana shape of galaxies.”</td>
</tr>
</tbody>
</table>
PROF. CHRIS DONE: “My research has been looking at evidence for black holes really being black, / Really having an event horizon”

“So, what I have been doing is comparing the things I think of as black holes / With things that we know are neutron stars,”

DR KATHY ROMER: “So, people like myself choose to map only the very largest objects in the universe, / These clusters of galaxies”

“In the survey I have been carrying out over the last four or five years”

“I use X-ray telescopes to study clusters of galaxies.”

“I find these clusters of galaxies using X-ray telescopes.”

Dr REKHA JAIN: “I do mathematical modelling, by solving some equations of physics,”

Table 10: Descriptions of working practice in the astronomy questions videos. Text, grammar and individuals’ titles are taken from closed captioning of the videos. A ’/’ indicates a new caption [ROG-WAG-V1-16].

Thus, although there is greater representation of women as expert scientists in this gallery than there were in the examples I discussed earlier in this chapter, these videos continue to articulate gendered expectations about roles that scientists can inhabit. The construction of these videos fits with existing research in other media domains conducted around the same time as the Weller Astronomy Gallery. Indeed, even when looking at literature on, for example, newspaper coverage, many of the same scientists discussed in other research are the same as those who appear in these videos. I would also like to draw attention to the composite nature of these films and their placement within the gallery –
scientists were interviewed (perhaps scripted, although unlikely as each scientist has a very different style of speaking in the videos), there were video editors who cut together the videos, there were curators and exhibition developers who may have been involved at points of development from the conception to signing off on the materials that now appear in the gallery. Taken together, there is no single ‘author’ of these videos, and the discussion that follows addresses how different agendas and societal expectations are enacted by various actors at different stages.

The data I have presented above demonstrate that these videos have greater numbers of men than women and no representation of non-binary individuals. Similarly, around the same time, Kitzinger et al. (2008) report that “[m]en are much more often cited as expert scientific sources than women. Newspaper reports of SET (Science, Engineering, Technology) quote five men for every one woman” (p.12). The standardised format of the title presentation and introduction in the videos mean that it is not possible to see differentiation in the description of each scientist; this also fits with findings of reporting scientists in newspaper media where there was “little difference in how men and women in SET are described when they are simply being introduced for expert comment” (Kitzinger et al., 2008 p.12). This equality of introduction but not representation of differently gendered individuals perhaps indicates that there is some recognition of the problems around gendered representation of science and technology professionals; efforts are made to address bias in the introduction of individuals are demonstrated, but there remains bias in their inclusion and representation.

This can also be seen in attending to the language used in reporting scientific actions by the individuals in the videos in the gallery. While the invitation to be in the video and the structure of presentation is not in the hands of the scientists interviewed, the content of their statement to some extent is. I leave space here for the possibility that editing has shaped the content too, but I believe that this argument is still valid as the words in the phrases in the cuts are still those spoken by the individual. In the exerts highlighted above,
the same pattern is visible as is the case in Wulff and Boettger’s work (2008) that looks at how students in education talk about scientific practice: “female writers use the passive to report and interpret findings; males use the passive to describe methods of analysis” but not the findings themselves. The choice of where ‘active’ language, including in particular the use of verbs in the first person singular or plural, is used feeds into other discussion around power, prestige and the resultant social control. Men, in these videos, claim more overt, scientifically-powerful acts of knowledge-making in describing their work (such as “We found from my research” [ROG-WAG-AQ-V5]), whereas women discuss process and action driven acts (such as “I have been carrying out” [ROG-WAG-AQ-V9]) when discussing their own research. Additionally, this method of ‘claiming’ scientific actions and knowledge is echoed around the walls of the Astronomy Questions Gallery, where all discoveries and quotations on the timelines and in the cabinets that make up this gallery are by men (e.g. “Galileo’s telescope shows” [ROG-WAG-AQ-T4]) or are genderless (e.g. “Chinese and Japanese astronomers” [ROG-WAG-AQ-T4]), with the exception of the inclusion of Jocelyn Bell. Bell, it is noted, with “Anthony Hewish[,] discover pulsars”, framing her work as only valuable as part of a collaborative exercise.

As a result, gendering is both shown and made through actions within the gallery. Institutional development of narratives about appropriate, gendered and sexualised ways of being in the galleries inform the visitors about appropriate, gendered performances to enact withing in the gallery. As theorised by West and Fenstermake, individuals in a society:

design their actions in relation to how they might be seen and described by others
... [holding themselves] accountable for their performance of that activity as women or as men. (italics in the original, West & Fenstermake, 1993, p.157)

It is, consequently, key to think about what institutions of society sanctify as the ‘correct’ performance of an activity by those who are women, men, or non-binary gender
individuals. Thus, internalised modes of description that permeate society inform the ways that the women and men featured represent themselves and are represented by those involved in constructing these videos, in turn informing the ways visitors will see possibilities for themselves. That the Astronomy Questions Gallery is part of the suite of Weller Astronomy Galleries with Astronomy Explores also demonstrates that gendering is both ‘seen and done’ in the videos (Astronomy Questions), then providing a space where visitors are then ‘seeing and doing’ these gendered performances too (Astronomy Explores). I will detail how these performances are developed and encouraged within the Astronomy Explores gallery later in this chapter.

A queer feminist approach to this question of ‘correct’ or ‘proper’ gendered performances here highlights the arbitrary, binarized traits that exist in the literature, and urges us not to reinscribe these gendered norms that attribute scientific prestige to some people and action and work to others. Similar to the importance of highlighting a range of historical individuals – and the challenges that resisting these ideas might have – there is significant value in developing ideas about what ‘achievement’ might be itself in order to pluralise inclusion in the gallery. I shall explore these ideas about what might motivate inclusion in the gallery space in a later chapter on the Queering the Science Museum tours.

4.2.3 Disloyal order

While sex and sexuality may not be directly discussed in the gallery, some sexualised images are present in the gallery spaces without context. One such image is found in the Exploring Space gallery of astronaut Robert Curbeam, as part of the series on Astronaut Life on ‘Keeping Clean’ [SM-ES-T24]. This is arguably the most sexualised of the images that are in that gallery space, given it is the only image across all three case studies of this thesis that is of a person topless, who in this context is showering in space. The image was included as part of a small update to the existing gallery in 2003/2004 for museum-wide
push to engage with Black History Month (Millard, personal correspondence). The change involved editing the ‘Living in Space’ panel to include two Black astronauts and to replace the central image that faces the visitor on entering the gallery (at the time of writing in 2020 where the Moon rock is displayed) to be an image of African American astronaut Mae Jemison (Millard, personal correspondence).

Curbeam is an eminent astronaut. As of early 2020, he holds the record for the greatest number of space walks on a single mission. However, he is not included in the gallery section on space walks, but rather on personal hygiene. Arguably, had Curbeam been included in the section on space walks, this could have contributed to narratives around ‘Black excellence’ (Sobande et al., 2020). Such narratives are modes of portrayal perceived as respectable ways of showing Blackness within the mainstream media, associated often with exceptionalism, and individualistic (often classed) ideas about what constitutes achievement. Other images of white astronauts in the Astronaut Life section are not shown in places where they are ‘exceptional’ in the field, so the inclusion of him in a section on space walks would suggest that the inclusion of a Black astronaut required exceptionalism (in addition to simply being an astronaut) in order to be included.

However, as the image is presented in the gallery, Curbeam is shown topless, with arms raised above his head in the action of washing his hair. Contrasted especially to the images of white men such as Goddard or von Braun who are suited and undertaking ‘scientific’ work (in front of a blackboard with equations on it, or reading military messages), this image has a very different tone and message about the place and role of Black men. Stam and Spence (1983) theorised that images of Blackness are drawn down from historic narratives of colonialism, and thus media and film continue to the spaces that engage in the intersection of race and colonialism. As colonialism is experienced differently in different geographies, it has been argued that media representations differ too (Pines, 1981), for instance, that Bogle’s analysis of different tropes in films including the black buck (2001) is US-specific, and such cinematic representations will be received
differently in the UK. Thus, even though Curbeam is an USA astronaut, and the image is
taken to cater to this audience, it is appropriate to think about how this image might be
received within the UK context.

It within this matrix that these encounters play out specifically sexualised and racialised
anxieties (Shohat, 1991), particularly between the Black man and the white woman. The
fetishization of the Black body has been and continues to be used as a method of
dehumanisation and sexual exploitation (Holmes, 2016), and the construction of hyper-
masculine and hyper-sexualisation of Black men is especially contrasted to feeble, white,
heterosexual womanhood (Joseph, 2017). This line of argument is particularly pertinent
in the Exploring Space gallery as the construction of a topless Curbeam can be contrasted
to the physically proximate infantilised display about Sharman that I have detailed earlier
in this chapter. Drawing on Fanon’s argument that Blackness is perceived to be a
particularly troublesome Otherness that is not possible to be assimilated, this different
depiction of Black men to white men in the gallery is troubling in itself, exemplifying
tropes that at once make ‘primitive’, hypersexual (Young, 1996) and “sexually
irresponsible” (Reynolds, 1997, p.97) subjects of Black men – creating challenging
narratives for heterosexual and queer (Icard, 1986) Black men alike to grapple with.

Thus, as Hall (1996b) argues, the media representation is both about becoming and being –
the cultural norms and values are always in the process of production, are are
simultaneously structurally shaped by the society around it. Theorisation of the media
representation of Black British men argues it is complicit in their demonization –
narratives of criminalisation and violence materially shaped the experiences of Black
British youth in the criminal justice system (Hall, 1978, 1996; Gilroy, 1987; Solomos, 1988).
Ongoing representation of young Black and minority ethnic young people in the British
media is as ‘criminal other’ (Davies et al., 2003) or as part of culture which is implicated
in the actions of social ills (e.g. Alexander, 2016; Hargrave, 2002; Poole, 2006; Sreberny
2002), including perceived underachievement (Doherty, 2017; Gillborn, 2015),
overrepresentation in the justice system, and sexual misconduct (Lewis, 2007) place blame on individuals rather than as structural problems. I argue that such images of Black bodies as this picture in the Exploring Space gallery consequently align with moral panic around perceived deviance of Black youth (Alexander, 2008) in the wider UK media, especially in the absence of many other narrative of Black scientists across the gallery spaces.

Given my thesis’ interest in queer feminist theory as a framing understanding of the material and its positioning in the gallery, it may seem curious that I have chosen a subject matter (space galleries) so apparently free of relationships and sex. I contend, however, that not only do particular constructs of heteronormativity pervade, but that it is only because of the lack of this discourse in public about sexuality in space science that the field can be considered this way. For instance, the Exploring Space Gallery had, until the summer of 2019, a reproduced copy of the drawing on the Pioneer Plaque – two idealised humans, “representative of humanity” (Macauley, 2012). Placed in the gallery to direct viewers to ‘futures’ of space travel, it opened a section on the distant realms of the solar system that space craft, including the two Pioneer probes, continue to travel to. However, across all three galleries in my thesis, this is one of the only examples that gestures towards romantic relationships in the human race. As I mentioned earlier in this chapter, the vast majority of images and displays of people are them working, or simply being, alone.

Brain-child of Carl Sagan (who is also featured in Astronomy Inspires and Astronomy Questions), this particular image travelled on a golden plaque on the 1970s Pioneer Missions that are currently travelling to the outer edges of our solar system. As with the later Voyager Plaque, these symbolic representations of humans, planets, pulsar stars and the probe itself were produced to help an imagined alien on finding the craft understand the beings that had sent the object. As Macauley (2012) describes, the images were drawn at short notice by Linda Sagan, Carl Sagan’s then wife. The people can be read as a heteronormative display, a couple: NASA identifies them as a man and a woman
(suggesting cis, biologically determined genders), who were originally meant to be holding hands, to represent that they were a couple. The image emphasises a particular understanding of heterosexual relationship, with the man actively waving while the woman stands by passively. Moreover, it follows ‘Greek statuary conventions’ with respect to the depiction of the genitals of the two individuals: the woman is not drawn with the pudendal cleft whereas the man has his genitals fully depicted.

Read together with Curbeam’s inclusion, there is a clear delineation of what ‘appropriate’ sexuality is in the gallery, who is able to occupy a sexual identity, and in what way(s). It is binary, heterosexual, and relies on stereotypical media depictions of particular bodies. Although to ‘queer’ public media such as museum exhibitions can do more than address identities and relationships in the gallery, I argue that there are elements of sexuality that should be considered within this space, as well as hints of stories’ spaces and gaps that could be populated and pluralised with these ideas in these galleries. Moreover, this section’s argument has demonstrated the lack of space within these galleries to explore a non-binary identity; or anything that sits outside of the binary man/woman dichotomy. There is not opportunity within these galleries to see non-binary identities as I emphasise throughout this thesis.

4.3 STEMM identities in the galleries

In her 2016 work *Innocent Experiments*, Onion explores how mid-twentieth century science toys for children construct gendered ideas about who should occupy which role and how. Much like the material I have covered above, she is explicit about how:

Although American adults often naturalized science play as a universal mode of engagement, fun for all modern children, the whiteness and maleness of the
children depicted in encyclopedias, toys and books implied that scientific hobbies were represented as the property of the privileged. (Onion, 2016, p.15)

However, she also extends her argument to consider how ideas around children scientists are themselves gendered. The idea that in adulthood there has been “a lost “love of science””, described in such terms as “associated with boyhood: “messiness,” “mischief,” “danger”” (p.166), tying this juvenile, child-like joy of science with characteristics of hegemonic boyhood rather than childhood in general. These expectations of the child as a “trickster, a mess, a force of nature; [embODYING] transgression against adult desires” (p.167) map closely onto expectations of gendered boyhood. As Onion suggests:

“Girls with toys” neither rhymes nor evokes the same vision of free, absorptive childhood play. (Onion, 2016, p.167)

Thus, more than just thinking about who is presented in these gallery spaces as role models, queer feminist critical pedagogy also urges a consideration about why types of language and knowledge are introduced as ‘scientific’ and how these are utilised to include or exclude the identities of visitors. Elsewhere in the science education literature, as I have covered in my literature review, there is evidence that use of specific language around scientific tasks maps onto gendered expectations of masculinity and femininity. Particularly notable has been work on the portrayal of science as something ‘difficult’ a field in which only smart people with innate ability are successful (Carlone, 2004), and science’s link with objectivity, rationality and therefore hegemonic masculinity (Brickhouse, 2001; Gilbert, 2001; Kleinman, 1998). As discussed in my literature review, it is the challenging of this linkage of masculinity and objectivity, rationality, and reason that forms a core strand of feminist critique in its application to science (e.g. Fox Keller, 1985; Haraway, 1988; Harding, 1986), as well as the converse challenge of introducing feminised traits, like subjectivity, emotion, and creativity, and valuing them as key ways of knowing in science too.
Interestingly, the ideas of messiness and mischief that Onion highlights in children’s science toys map well onto more creative and subjective experimentation and less onto the rationality and objectivity that scientific narratives often centre on. In the concluding section of her book, however, Onion evidences a push back from women in scientific practice who see aspects of science that are “complex, boring, bureaucratic … rarely [giving] that feeling of excitement” (Onion, 2016, p.168) – practicalities that have been focused on elsewhere in campaigns such as People Like Me (Macdonald, 2014) and Science Capital (Science Museum Group, 2018). These campaigns showcase how skills such as project management and planning are essential to contemporary scientific pursuits.

It is also vital to recognise that the gendered nature of these skills or attributes changes over history and in various geographical locations, and that there is variability in the skills or attributes that are thought important for different ‘types’ of STEMM careers as well. This is demonstrated in looking at the movement of computer programming from being a low skill, repetitive, mundane task that that would and should be done by women who were gendered by the society of the early twentieth century to be good at such tasks to being a creative, complex, and high value job in the twenty-first century (Light, 1999). The ability to problem solve, demonstrate meticulous attention to detail, and think through long problems for overarching mechanisms for solutions have changed little, but the societal value placed on such skills, and the correlating gendering of them, has. Such demonstrations of gendered exercises of power in designating knowledge valuable or important happen in the opposite direction as well. For example, the movement of sewing from being highly skilled profession – worth training and paying large sums for – occupied by men around the 16th century, to being a domestic, trivial occupation to pass time for women charts an opposite change in power and prestige (Hunter, 2018). It is not for nothing that recordings of (majority white) women who stitched computer programmes for the Apollo II mission at Raytheon have gone unnoticed until the 50th
Anniversary of the Moon landings, nor that in recovering this history the record
privileges their programme manager, Robert Zagrodnick, who is cited in an anniversary
articles that names none of the women in the team (Raytheon, 2019). Thus, rather than
understanding traits as universally masculinised or feminised, especially as different
galleries in this analysis were composed at different times, I will attend to thinking about
whether these skills have been binarized and how attention to this could help subvert and
challenge these constructions.

After all, it is not just that, as hooks’ eloquently describes, “half of our human traits are
exalted while the other half is devalued” (hooks, 2004, p.33), but that socially we
somehow believe we can separate traits out in the first instance. For example, in trying to
counteract existing narratives of historical women as non-active participants in STEMM,
response narratives emerge that can range from flattening multidimensional personalities
and skills to forcing canonical excellence of these individuals for whom records do exist
(e.g. Stenhouse, 2019) to ones that characterise all scientists against the ‘masculine’ ideal
of typified science – “endurance, competitiveness, physicality, bravery, and grit” (Des
Jardins, 2010, p.120). So, instead of mapping ‘traits’ directly onto masculinity and
femininity as has been done elsewhere (for example, in Dam et al., 2014; Francis, 2000;
Nicolaisen and Achiam, 2019; Silfver, 2018), I will be considering if traits are coincident,
and what other aspects of the gallery they are seen with, and what this might tell us about
the pedagogies implicit in these galleries.

I argue that the need to reject the mapping of gendered identities onto sexed bodies of
learners runs deeper, in that this hegemonic account leaves no space for understanding
the way those with marginalised gender and sex identities (e.g. gender queer, non-binary
or intersex) can understand themselves in relation to these binary categories. Torres
(2012) argues that by only trying to understand these traits along a singular axis of
masculinity-femininity, which is hegemonically strongly co-constructed with white
ideals, we can inadvertently push uniform or unified types of narratives onto those with
intersectional identities who are not historically considered by hegemonic masculinity – leaving out the diverse experience of how different traits are coded differently when read against intersectional racialised, classed, and disabled identities. Previous moves towards challenging these positions include understanding power relations in terms of monoglossia/heteroglossia (Bakhtin, 1981) along a gendered axis. In relation to gender and education, Francis argues that these terms can be understood such that ‘monoglossia’ is the “dominant form[s] of language representing the world-view/interests of dominant social groups”, mapped onto “masculinist social epistemologies”, but that on the microlevel, these forms are not static, fixed or unchanging. Rather, these forms are “constantly jostling in assertions or subversions as subjects use language in different ways” (Francis, 2010, p.479) and “always a façade” (Francis, 2010, p.480) in need of maintenance. While others, as above, have detailed binarized understandings of traits, ‘heteroglossia’ for Francis instead represented a “fluid multiplicity” that rejects a binary account of gender difference. This is important for my work as it grapples with the changing and constantly renegotiated gendered ideas that I discussed earlier. However, I believe Francis’ conceptual application of this framework insufficiently theorises the application of Bakhtin’s categories onto gender as it too neglects the co-construction of different femininities and masculinities in relation to other intersecting identities.

Questions arise about the extent to which these ‘traits’ are mapped onto the ways that science is encouraged in the galleries. In my literature review I explored how not only can the ways these ideas are expressed be perceived differently by different people at different times or in different constructions, but they might also map onto genders, as gendered constructs are both unstable (Butler, 1990; Harding, 1986) and continually developing (Riessman, 1987) and do not have to be binary (e.g. Fausto-Sterling, 1993). I resurface these explorations here, especially in relation to the monoglossia/heteroglossia distinction above, noting that these constructions come from a white, capitalist, patriarchally informed understanding of genders (binaohan, 2014; hooks, 2004), and that these traits remain sites of contested exploration. I will instrumentalise these traits with
caution – thinking more explicitly about how the traits are located and how they fit with hegemonic narratives of (gendered) science.

Whilst there are many possible axes of consideration, I will particularly focus in this section on the way that ‘gendered’ ways of doing science emerge as themes in the galleries. I will first consider the way that ‘active’ participation is depicted and in relation to whom; I will then discuss how narratives of individual and collective endeavours are created in the gallery spaces. Throughout both thematic discussions, I will address the way these categories construct ‘us’ as the visitors, as well as the interplay with ‘them’ as a professional scientific identity gestured to in the games.

4.3.1 Homesick at Space Camp

The characteristics of science often used to encourage people into doing science – the “messiness”, “mischief” and “danger”’” (Onion, 2016, p.166) – are perhaps at odds with the way that science is described in the galleries. I have demonstrated that the increased inclusion of people (scientists, astronomers, publics) and active contribution to scientific practice by people is part of what I believe to be a feminist turn in the curation of science galleries. To make science more ‘accessible’ to more people, activities (broadly constructed) have been introduced into gallery spaces. However, rather than seeing this as an active/passive divide, theorists on interactive galleries have explored how different types of activity (collaborative/individual, open-ended/closed) might encourage differently gendered individuals based on social gendering of traits (e.g. Dancstep & Sindorf, 2018a).

Overall, the minority of figures in any of the galleries are seen ‘active’ in science. I have already highlighted, in Section 4.2.2, how it is infrequent that scientists are depicted doing their research. With respect to the videos of scientists in Astronomy Questions, I demonstrated how the majority of professionals who are featured are reporting on results
(conforming with ‘objective’ science), rather than discussing their research. I demonstrated how this reiterated findings that women in discussing science were more likely to “use the passive to report and interpret findings” whereas men used the passive to “describe methods of analysis” but not their findings (Wulff & Boettger, 2018, §21). The reciprocal of this was where the activity was situated – where gendered differences were seen in women discussing the acts of science in an active tense. However, across these videos there are no examples of footage of researchers doing work – the videos are of people sitting discussing their work – and any images of research either lack people or are diagrammatic. Thus, this gallery still manifests a ‘passive’ reporting of science, continuing to favour a mode of engagement that characterises western masculine science, rather than providing opportunities to explore plurality in the practice of science.

By contrast, the interactive format of the Weller Astronomy Galleries: Astronomy Explores allows science to be positioned explicitly as an activity first and foremost, rather than a history of science narrative with some points of interaction as seems to be the case for the Exploring Space gallery. The extreme passivity of the information communicated in the From the Beginning gallery, where no ‘active’ exploration is present, fits into historically abstracted, masculine narratives about science not being ‘done’ but rather reported after the event by a ‘neutral’, ‘objective’, omnipotent observer (Prescod-Weinstein, 2019). In constructing this passivity, it is possible to easily lose touch of the contingencies and choices made both in doing the research and in representing the research, such that it is almost impossible to see that:

if problems are necessarily value-laden, if theories are constructed to explain problems, if methodologies are always theory-laden, and if observations are methodology-laden, can there be value-neutral design and interpretation of research? (Harding, 1986, pp.22-23)
Earlier in this chapter I also detailed the way that technicians are featured without names (Shapin, 1989), and noted that they were often the only ones seen in action ‘working’ in the galleries, exploring in detail the reiteration of gendered types of work that are featured in the gallery spaces. However, there are some other individuals that appear to be ‘active’ in their research pursuits – for instance, the unnamed scientist interrogating the Hubble Data Set in the planetary science section of the Exploring Space gallery is ‘active’ at a computer, not looking at the camera; instead, focused on the screen of ‘data’, backgrounded with images from Hubble on a poster board. Captioned below the image:

Every day, Hubble sends back several DVDs worth of information. This is archived on the internet to be downloaded and studied by astronomers all over the world. You can see many of Hubble’s most significant images at www.hubblesite.org (SM-ES-T12)

an allusion to this being what the data being “studied by astronomers all over the world” [SM-ES-T12] would look like in practice. Viewing this image and reading the caption we are directed to see the data as the important feature. The dataset is explicitly named and described in the caption, and the astronomer who is included is not named and is shown looking at the data on a computer. We, directed by the people captured within these images, are encouraged to see these data as being the focus of the image, removing the activity of the researcher as a data-interpreter, and instead understanding the data themselves as ‘science’ (Vertesi, 2015). This positioning of the human in the planetary science section of the Exploring Space gallery is especially interesting as there is almost no agency ascribed to workers on space craft here.

The absence of evidence of active work being done on Earth to direct, develop or create knowledge from the work of spacecraft in space or on other planetary bodies in the planetary science section is in direct contrast to the activity of human spaceflight seen in the gallery. Many images in Exploring Space are of the Apollo astronauts on the Moon, in
addition to two large figures that appear to be ‘active’ in their exploration of the diorama of the ‘lunar surface’ that has been created within the gallery space. Moreover, these images are ‘active’: there are many images of astronauts ‘doing’ things on the ISS – including astronauts on space walks outside of the main module of the ISS, fixing the Hubble telescope, exercising. Focusing on particular types of work (e.g. being an astronaut but not being an engineer) as worthy of inclusion contributes to the types of gendered exclusions seen in the gallery as a result of assumptions about both who does the role and what the role is. These stereotypes are themselves constructed along binary lines. As such, the woman astronaut is an exception because she crosses over into male territory of what it is to have the right stuff (Wolfe, 1979) to be an astronaut. Indeed, this very conceit has been explored in, for example, centring the experience of the Mercury 13, Dr Lovelace’s cohort of experienced female pilots training to astronaut standards and their experience of sexism in the suitability of the profession (Weitekamp, 2006). This queer feminist critique can be a way of exposing and challenging this binary division of the appropriateness of particular genders (or sexes, depending on how accounts are written) to particular roles.

4.3.2 Where did the party go? Individualism or collective work

Conversely, alongside the narrative of the ‘objective’ empiricist, passively describing the work done in scientific research, there are different representations of how active science could be constructed. I take as a case study two games, one in Exploring Space (henceforth referred to as Your Mission) that opens by asking:

Your mission: design a lander to touch down on another world.

The lander must survive its journey and touch down ready to carry out scientific investigations.
and a second in Astronomy Explores that is titled “Build a Space Probe” [ROG-WAG-AE-II]. Both develop an ‘active’ engagement for the visitor in the process of designing a (simplified) space probe, and both use similar examples of destinations for the probes to go to (e.g. planets, moons). Both take a similar format of the digital touch screen and allow selecting options after a series of instructions are given on screen. Such similarities provide an opportunity to think critically about the pedagogical choices of narrative around the collaborative work encouraged, the ways that actions are described, the engagement with real world settings, and the representation implicit in the games. Using the arguments of Dancstep and Sindorf (2018a, 2018b) for a Female-Responsive Design Framework that I covered in my Methods chapter, I will consider whether ways of emulating the collective work in science and technology museum interactives, and including these feminist intentions, provide a way of exploring a queer feminist approach to engaging with science practice and scientific identities, and challenging masculine or feminine conceptions of science practice.

4.3.2.1 Collaborative work

Dancstep and Sindorf (2018a, 2018b) argue that on mode of challenge to the way masculinised science is presented is to centre collaborative work in an interaction, facilitated by an interactive being able to be used by more than one person at the same time, providing opportunities to work with others, and to encouraging discussion.

In Astronomy Explores, Build a Space Probe has three separate stations (Humphrey & Gutwill, 2005) with space for three groups to work at the different tasks (Borun & Dritsas, 1997; Borun 1999). In my field work notes I once recorded a visiting group of five, split into three groups at the stations; another time a larger school group split into groups of five to six playing on the controls. The touch screen interactives can only be used by
one pair of hands at a time – but each can be used from three sides. Each position has a required role (Chief Engineer, Lead Scientist, Comms Officer [ROG-WAG-AE-II]) with distinct role responsibilities (Advisor Contributions, 2007; Borun & Dritsas, 1997; Borun, 1999) – one at each station. As the game requires three different roles to be filled, the game is also set up such that if there are not three people, it will auto play the roles that are left vacant, still allowing the idea of collaborative work if there aren’t other people to collaborate with.

Read against this is the set up for Your Mission – a single touch screen (Humphrey & Gutwill, 2005), which can only be used from one direction (Advisor Contributions, 2007; Borun & Dritsas, 1997; Borun, 199). During my field work, I did notice visitors trying to use it together, but there is not space around the control for multiple people and most groups gave up quickly after attempting this (Borun & Dritsas, 1997; Borun, 199).

More than simply providing separate spaces for multiple people, Build a Space Probe explicitly invites visitors to work together (Perry, 2012; Simon, 2010) with instructions such as:

This is a group decision …

It’s a team job to keep the Probe below its maximum weight, so talk to each other and work together to keep the Probe light.

… I’m sure you’ll be able to iron out the problems together. Now we know what to change to get things right for next time … [ROG-WAG-AE-II]

These instructions do give space for individual decisions (selecting two instruments each), and then suggest a comparison – particularly around a collective weight limitation on the Probe. By contrast, Your Mission invites only the engineering role to be considered
– the visitor must vary different components of the “Airbags”, “Heat shield” or “Main Parachute” [SM-ES-I3]. There still exists the limitation of a “Total weight”, which the player is asked:

You’ll need to use all the available weight but you mustn’t go over the limit, so keep an eye on the total. [SM-ES-I3]

There is no comparison between different ways of designing the space probe, not between the player and previous visitors work, nor comparison to real spacecraft (Advisor Contributions, 2007). Thus, against the collaborative model of interactives that Dancstep and Sindorf (2018a, 2018b) propose, the Build a Space Probe better models practices that are deemed by the framework to be encouraging to collaboration, and thus, girls, in gallery spaces than Your Mission.

This not only allows better collaboration – a pedagogical approached theorised to help engagement of those otherwise excluded from science education (Brotman & Moore, 2007) – but the collaboration also better emulates the modes of work that are common in space science projects. Large national and international organisations dominate the landscape in space science research – publicly funded space agencies such as NASA, ESA, JAXA, Roscosmos, as well as public-private hybrid collaborations between companies, such as Space X, Virgin Galactic and Reaction Engines work in collaboration with each other and across different areas of expertise within the organisations themselves. Even beyond space science, collaborative practice is common across ‘big science’ (e.g. Canals et al., 2017), and thinking about ways of demonstrating this networked approach to science is seen in other galleries, such as the Science and Technology galleries at the National Museums Scotland.

4.3.2.2 Real world setting
The setting for the development of the craft differs between the two games. In *Your Mission*, the development takes places against a blueprint background, which I read as a stand in for the process of design, development and planning before building – a literal ‘blueprint’ for the mission. There is a narrative voice giving instructions to ‘you’, the participant, thus co-locating the visitor in the development, but these instructions are issued from nowhere, and are without an apparent author.

By contrast, *Build a Space Probe* has a video and a series of ‘digital environments’. The video situates the apparent director of the space probe project (identified thus by the description “I need to fill three key positions in my team” [ROG-WAG-AE-I]), in what visually matches a mission control room, replete with computer monitors, desks and the backs of people’s heads. This director is dressed in a suit, white shirt and black blazer, and appears to be a white man. All other people visible in the shot of the mission control appear to be white man too, as is the BSL signer present in the bottom righthand of the screen. The digital screens on which the displays are located are black with yellow writing, echoing a command-line style for the computation processes.

Whilst both games locate the exhibit phenomena in the real world (Advisor Contributions, 2007), which Dancstep and Sindorf (2018a, 2018b) argue is a way of challenging hegemonic presentation of science, *Your Mission* provides considerably less context than *Build a Space Probe*. Unlike *Build a Space Probe*, *Your Mission* doesn’t have any images of scientists, other STEMM professionals or people more generally, and provides no context about the roles of STEMM professionals (Advisor Contributions, 2007). By contrast, in *Build a Space Probe*, not only is there a person delivering the content and ‘leading’ the team, the individual roles are given a specific subset of skills with active language about the actions of that professional, for example:

- **Comms Officer**
  Designs systems that:
o Talk to the Probe
o Guide the Probe
o Handle the data [ROG-WAG-AE-II]

The activity of the professional (“designs”) helps place the visitor in the real-world context of the role. However, even in this case the limitations of the collaborative game are clear. There are no women or non-binary folk in this display, and everyone in the images is white – *Build a Space Probe* does not actively work to subvert or challenge who could be a scientist or part of the mission team (Advisor Contributions, 2007; Crowley, 2007; Crowley et al., 2001; Onkka & Bequette, 2014). Especially when viewed against the demographic data for collaborative mission teams, this could have provided a space to explore and confirm the self-image alternative identities of people working in mission teams. Thus, in both cases, even if *Build a Space Probe* has people seen in the real-life situation, a hegemonic masculine science is still present. The ‘real-life’ presented remains one dominated, especially at the senior level, by the white men in these fictional narratives.

Both programmes have answers for ‘success’ or ‘failure’ of the probe being developed. The failure of the probe in *Your Mission* plays out in animation on screen, ending with words such as “Splat!” [SM-ES-I3] after the cutscene that explain the failure. The ‘real world’ setting is slightly lost as the action takes place on a low-resolution rendering of the planetary body that is travelled to, in a way that would not be possible to see as either a member of the public or as a researcher on the project. By contrast, the Astronomy Explores *Build a Space Probe* sees the take-off of the Space Shuttle, followed by newspaper headlines (e.g. “Probe fails: Instrument mixup”), and reads the first sentence of the ‘news report’ out loud:
Despite travelling hundreds of millions of miles to perform important science experiments, the latest Probe is utterly useless, and all because the probe team put the wrong instruments on board! [ROG-WAG-AE-II]

Similar to the presentation of the mission failure of Beagle 2 (nearby to these games in each gallery), the Astronomy Explores game only reports back the failure, and does not show the failure of the device. This second mode relies more on knowledge of English – without being able to read the ‘newspaper’, subtitles or hear the speaker, it would be hard to know of the failure. Thus, I argue that the failure of Your Mission allows more visual confirmation (and therefore perhaps more certainty for the visitor) of the failure of the Probe. As a context, however, the introduction of a newspaper allows a pedagogical link between the work done as part of the game and an item that might be recognisable from visitors’ lives outside of this visit – using a familiar object in a novel way (Advisor Contributions, 2007). The font in the paper (a visual match for Times Roman) might also help us understand a bit about the implied visitors’ newspaper readership – perhaps of broadsheet newspapers as opposed to tabloids, and with it a classed, intellectual expectation of the visitor (Dawson, 2018; Falk, 2016) if this newspaper is to be understood as an object that the visitor is familiar with.

4.3.2.3 Interaction description

As a result of the differing settings of the games, the context of failure (if the player is unsuccessful in the game) is also presented differently. I use these descriptions as a way of articulating ideas about the modes of interaction (and re-interaction to encourage a player to replay the game for a success) that are prioritised in these two games. After a failure, the following messages appear:
In real life, it would take years of research and millions of pounds to launch another lander mission, and there might not be another chance of a long time. But you’re lucky – in this game you can try again. [SM-ES-I3]

Well, that was a disappointment. I’m sure you’ll be able to iron out the problems together. Now we know what to change to get things right for next time. Thanks to efforts like this, humankind is reaching out even further into space, so don’t stop now! Let’s continue our space exploration. [ROG-WAG-AE-II]

In *Build a Space Probe* the exercise of developing the space probe is clearly expensive and well publicised as the final sequences are depicted in a rocket launch and as being covered in the newspaper. However, the call to action is based on comradery (“Now we know ...”, “our space exploration”), and a sense of fitting into a ‘grander’ narrative about the purpose of pursuit of space science through the use of “humankind is reaching out even further into space”. By contrast, the failure of the space probe in *Your Mission* reinforces the fictive nature of the game (“In real life”), and the financial cost (“years of research and millions of pounds”). Thus, the encouragement in *Build a Space Probe* is not through competition with other teams, as might be expected in a more overtly nationalist narratives, nor through any negative blame for failure and the exceptional nature of the game, but instead through a direction towards a ‘purpose’ of space science. This mode of encouragement reflects some of Dancstep and Sindorf’s arguments that showing the relevance of the game to ‘real world’ tasks is encouraging for ‘females’ (2018a, 2018b). However, in the following chapter I will be thinking more critically about to whom this ‘purpose’ of humankind’s mission into space is appealing. Already, through this chapter, I would argue that the ‘real world’ of space science has been set up as an extremely masculine domain, and thus, although this appeal may be meant to draw in previously excluded participants, it perhaps reiterates their exclusion.
Drawing together the analysis threads of these three modes of exploration of the game, I argue that although Build a Space Probe adheres to many of the modes of engagement suggested by Dancstep and Sindorf (2018a, 2018b), this does not in and of itself make the game more accessible. Additionally, to design the game exclusively as an object with feminist intentions, and then to deliver it into a gallery that centres on masculinity is neither challenging nor changes the existing narratives around who is valuable in space science work in the rest of the gallery.

4.4 Summary

In this chapter I have explored the presentation of individuals and the construction of the visitor in the gallery spaces. I have particularly sought to address gendered expectations about who does what work, and how these ideas pervade the construction of images, the way people talk about their work and themselves, and the types of behaviours that people are seen doing in the galleries through the representation of scientists and through the types of interactives that are available for visitors to engage with in the galleries. This chapter has explored both my first and second research questions explicitly in relation to the types of STEMM professionals and STEMM activities on display. In the following chapter I explore the way locating practices of space science through a visual and geographical lexicon that also permits and excludes particular identities. Thus, moving from thinking about individuals in isolation, Chapter 5 looks to address embedded narratives and imaginaries that persist in the galleries through the contexts of geographies.
Chapter 5 Making Space(s)

LGBTQ+ or gender identities of individuals featured in gallery developments have been a fulcrum for understanding gender and sexuality in galleries (e.g. Winchester 2013), as well as a mode of thinking about equity in science fields. However, led by the questions expressed in my methodology, I argue that narratives are embedded more deeply in museum galleries than just in the people who are featured (or absent) in the gallery. Thus, this chapter, guided by my first two research questions, asks about the context of the science, technology, engineering, mathematics or medicine that is constructed in the gallery:

1. What gender and sexuality narratives exist within London space science galleries in relation to the STEMM content?
2. By being attentive to the presence of the curated gallery space, what knowledge is absent from the gallery?

Moreover, much as I have demonstrated in the previous chapter, by attending critically to the material in the gallery, I will use this information to think about who the intended audience is for the exhibits at the museums I am using as my case studies.

I will make my argument in this chapter in three sections. First, scaffolded by Messeri’s concept of making place in Outer Space (2016), I explore the ‘places’ that are constructed and who they are ‘for’ in the galleries that I have studied. Second, by widening the concept of making place as a way of constructing epistemic knowledge, I draw on making an inverse argument about what is not in the galleries as demonstrated by Haraway (1984), and demonstrate knowledges that are not created or valued in the gallery spaces. Ultimately, in this chapter I build towards my final point of the argument: that there is significant overlap in the ways space science is characterised as ‘objective’ (or ‘universal’).
and ‘relational’ (or ‘Earth-like’) in the galleries, and that this overlap facilitates the mapping of masculinised western science onto a universalised knowledge of space.

Within this overarching argument, I will demonstrate that space can be understood as an articulation of international soft power and will show how these national narratives are created in my case study galleries. I will then briefly indicate how these ideas of national talent feed into designations of ‘craft’ technologies and are read against ‘mass manufacture’, in ways that reinforce orientalist and colonial positions. Finally, included in this argument and informed by Kessler’s readings of Hubble Images (2011) and Vertesi’s work Seeing like a Rover (2015), I will look at the work that galleries do to ‘teach’ visitors to read data as images. By critically examining the origins of the visual and spatial semiotic language the galleries rely on to do this construction, I will add an additional strand to my argument about the types of power and knowledges that are implicit in the narratives constructed in the space science galleries of my thesis.

5.1 Making place

Space – in the sense of everything that exists beyond what we consider to be Earth – is expansive, unfamiliar and unlike anything terrestrial. However, making these unfamiliar locations in Outer Space seem like recognisable places to knowers allows individuals to become familiar with extra-terrestrial landscapes that are distant and difficult to conceptualise. In order to do such work on objects in space (such as, for example, planets) Messeri argues that:

Scientific practice transforms planets from objects into places, and this movement is an essential way of knowing and doing planetary science. (italics in original; Messeri, 2016, p.9)
Like space, place is itself a constructed phenomenon – articulated differently by different scholars at different points in time and on different scales. ‘Place’ has been theorised against ‘space’ as a category (Buttimer & Seamon, 1980; Harvey, 1993; Merrifield, 1993; Tuan, 1977) where the former is localised in meaningful subdivisions of the latter, making ‘space’ itself universal and a priori. Categorising thus, ‘space’ can be constructed as objective, and as such a ‘masculine’ locale; making ‘place’ by opposition a feminine subjective category. This binarization can be challenged – neither category is as neat, unified or apolitical. ‘Place’ can be pluralised through, for example, historical (Kern, 2003), social (Lefebvre, 1974), process oriented (Pred, 1984) or political (Zukin, 1993) iterations of the concept, demonstrating the term as disparate and changeable (Massey, 2005). Similarly, rather than thinking about ‘space’ as a universal, other theorists have challenged the neatness of the category. For example, using Earth-wide concepts of ‘the planetarity’ (Gilroy, 2005; Spivak, 2003) alludes to the inhomogeneity of the world and relationships across the planet, and to escaping the flattening of international exchanges or assumptions of the “imposition of the space system of exchange everywhere” (Spivak, 2003, p.72). Similarly, challenging the importance of knowing ‘space’ first as a universal and then local ‘place’ as a secondary can encourage the use of knowing a location in relation to ourselves as a primary way of knowing. This allows us to see ourselves as more closely tied to our place in the terrestrial environment we are a part of, to break down nature-culture divides (Haraway, 2013), and move towards, for example, terms including Anthropocene (e.g. Chakrabarty, 2009) to describe climactic shifts that relate the human to place. Arguably, however, there are still problems with these moves. For instance, Anthropocene places the root of ‘anthro-’ as the prefix positions the human ‘before’ the environment, whilst also flattening the impact of ‘humanity’ into a single entity instead drawing attention to the ongoing climate crisis being the impact of primarily white, western lifestyles on the environment. As a result, terms including, for instance, Capitalocene (Moore, 2016) situate human society’s relationship to the environment temporally and well as planetarily through tying the actions explicitly to a western economic system as giving rise to the ongoing crisis. Thus, it is integral to think of ‘space’ and ‘place’ (which conceptually and lexically might be mapped onto ‘there’ and ‘here’
respectively) as intimately related and relational to the knower and the constructor of epistemic meaning. I will utilise thinking critically about the ‘places’ that are constructed in the galleries to interrogate where ‘here’ is, and, further, to whom this ‘here’ might be expected to be in relation. In this first section of the chapter, I will use Messeri’s ‘making place’ to further answers to my first research question.

5.1.1 Making place in Outer Space Galleries

The act of place-making is not accidental:

Place, I argue, is not just a passive canvas on which action occurs but an active way of knowing worlds. (Messeri, 2016, p.190)

Rather than simply seeing place-making as a practical act, Messeri argues that it is an epistemic assertion and action about how we can understand the world and other worlds – a way of “generating scientific knowledge” (Messeri, 2016, p.190). Through her ethnographic study, Messeri argues that there is something ontologically special about the ways planetary scientists use place making to make their work knowable, such that it articulates “a desire to intimately know planets as worlds on which one can imagine being” (Messeri, 2016, p.190). I argue that because galleries in science museums are informed by popular culture generally, and scientists specifically (through objects donated or discussions with curators), the same ontological motivations of place-making bleed through into the galleries I have been studying.

Creating a world that is relatable to Earthly experience is a motivation at the From the Beginning Gallery, where the temperatures and gravities of other planets are scaled against Earth. Each planet has three interactive buttons – ‘Temperature’, ‘Gravity’, ‘Fact’ – which when pressed light up a display to the right hand-side of the images of the planet. On approaching the interactive, “Earth’s surface temperature range” (-89°C to +58°C) [NHM-FTB-15] is illuminated by the side of each planet, illustrated with small snowflakes
Figure 9: An example of the scaled temperature and gravity of planets against Earth in From the Beginning, Natural History Museum, Summer 2019 (Image credit: E. S. Armstrong).
for temperatures below zero, and sunshines for temperatures above. On pushing a yellow-orange backlit button marked ‘Temp’, the planets’ ‘average surface temperature’ is lit up, with a value, and additional snowflakes or sunshines are illuminated to fill the section between Earth and the planet being looked at (see Figure 9). In the gallery, the scale and numbers provide an indication to visitors about the temperature. Because the symbols for numbers transcend language barriers, these were during my time in the galleries often utilised by groups not speaking English, where the adult would use the concept of “colder” or “hotter” and the numbers in order to relate the exhibits to non-English speaking young people. While the scales were popular with young children, as the ‘scale’ allowed them to relate the ‘planet’ temperature to their own experience on Earth, the buttons that are required to be pushed to get this information were situated at around 1.2 m from the floor, and as such out of reach of many smaller children. The same relational construction occurs for gravity; using small illustrations of ‘masses’, “Earth’s gravity” is related to the planet’s gravity, this time with a small caption as to whether the planet’s gravity is weaker or stronger than Earth’s (e.g. “Uranus’ gravity a little weaker than Earth’s gravity” or “Jupiter’s gravity more than twice the pull of Earth’s gravity” (NHM-FTB-8 and NHM-FTB-T10, emphasis in the original)).

This imaginative relational construction places Earth at the centre of experiences and relates all other planets to it – constructing our terrestrial home as ‘normal’ and all other solar planets in relation to it. This centres the human experience of the visitor as the central point of reference for imagining places in Outer Space. The relational framing can particularly be seen as a way of making humanity epistemically invaluable for knowing about the world by contrasting this to other galleries. For example, in the Astronomy Inspires video at the Royal Observatory Greenwich, where the same data are presented in isolation, for Neptune the “Cloud top temperature -220°C” is presented in relation to other data on the planet (Number of Moons: 13; Mass (Earth = 1): 17.1; 4.5 billion km) (RMG-AI-V1). All four of our solar system’s gas giants are shown on the screen at once, with a minimum of four data values situated, moving, in relation to each for under 5
seconds. In these two examples the same data are being used to different pedagogical ends— in the From the Beginning Gallery these are used as a way of creating relational knowledge (e.g. Emekauwa, 2004; Gruenewald, 2003; O’Connor & Sharp, 2013; Woodhouse & Knapp, 2000) centring the Earth as the reference ‘place’, whereas in Astronomy Inspires the data are presented as a visual and numeric shorthand for ‘scientific’ ways of knowing, valuing a ‘view from nowhere’ and objectivity as central to the practice of astronomy. Here, place has been made as being outside of the terrestrial vantage point from which we are constructing the knowledge, suggesting a universality and abstraction which I will return to later.

A similar exercise is done in creating place in the ways that planetary ‘views’ are shown. At a number of the planet stations in From the Beginning, the depictions of the solar body are made to look like they are taken “from the landscape” view on the planet (e.g. Pluto and its moons – NASA, ESA and G. Bacon; Asteroid Ida [NHM-FTB-T6] “as old as the earth” [NHM-FTB-T11]; Earth Rise on the Moon as “Earth’s satellite [NHM-FTB-T14]). Positioning the viewer as located ‘on’ these bodies gives an experience of being ‘in the place’, again helping the visitor to position themselves using a relational form of knowledge making. These views of inserting the visitor ‘in’ the landscape are also seen at work in the Exploring Space gallery, where both a Martian and Lunar landscape views are constructed as if we were on the surfaces of these planetary bodies.

In the case of the Lunar landscape, a section of the gallery is converted into a life-size diorama of the Moon, complete with Apollo 11 Eagle Lander, Apollo astronauts and other Lunar technology. Much like a zoo cage, there is a small barrier that encircles this fictional landscape with texts and images positioned at intervals around it explaining different parts of the diorama to visitors. Inserting the visitor directly into the diorama is achieved through the scale, the centrality of the diorama to the gallery and by questions that focus on the visitor on the panels such as:

Could the next footprint on the Moon be yours? (SM-ES-T14)
Elsewhere, some distance is created between the visitor and possible inhabitants of the Lunar setting through these texts situated around the edge of the Lunar diorama:

Now NASA and other space agencies want people to return. This time humans will stay longer and explore more widely to learn more about our rocky neighbour, and how to live and work safely on other worlds. (SM-ES-T16)

Terms such as “humans” or “people” in this example, are not as proximate to the visitor (“you”), and suggest that the ‘place’ created is somewhere that the visitor might observe but not necessarily participate in. Some of the work done by the Martian diorama will be interrogated in Section 5.1.3, but it too positions the visitor in the gallery as a viewer onto the landscape of another planet, aiding in making this ‘space’ a ‘place’ that the visitor could be part of.

These efforts of ‘place making’ can be compared to, for example, the projections of global maps in the Science on a Sphere in the Exploring Space gallery. The depiction of an exoplanet that appears in the video sequence is narrated:

This planet looks like Earth but it is actually an artist’s impression of what a distant Earth-like planet might look like. In this imagined world you can see continents, oceans, and clusters of cloud. The Kepler spacecraft has discovered over a thousand planets in other solar systems. We call these worlds ‘exoplanets’ and some are believed to have the right conditions to support life. However vast distances separate us from most exoplanets. One recently discovered exoplanet, Kepler 452-b, is fourteen hundred light years from the Earth. This means light would take fourteen hundred years to reach us, and a spacecraft would take twenty-five million years. [SM-ES-V6]
Use of terms that include the visitor (“we”, “us”), links from the image to familiar terrestrial concepts of places (“continents, oceans and clusters of clouds”), as well as the projection providing a visual match for Earth using blue and green colouring give the impression of an extremely “Earth-like” planet, complete with chlorophyll-based plant life. Whilst collecting data, I noted that many young people mistook this ‘planet’ for Earth, with their adults having to draw their attention to the fact the “continents” do not look those that they might be familiar with from looking at the Earth. Indeed, this fallacy echoes what Stern terms the American technological sublime, finding oneself:

    gazing down on a planet which appears untouched by human culture, the astronaut-subject sees the unseeable, the pre-historic, pre-human Earth. He is timeless, bodiless, primordial; containing time and space within his all-encompassing gaze. (Stern, 2000, p.205)

The place-making has happened so well here that visitors, used to seeing an overview of Earth from satellite images, are encouraged to read this as another planet that humans could live on, even if it would take an impossibly long time for any individual human to reach this ‘place’.

Thus, in the galleries, by “mapping and visualizing other planets” the exhibits, videos, interactives and artefacts are able to “[translate] the strange and unknown into the sensorially relatable” for visitors to the space (Messeri, 2016, p.18). In this section I have demonstrated that different modes of making these planets or astral bodies knowable are used in my case study galleries. There is clear, relational epistemic place-making in relation to the Earth and our terrestrial experience, as well as ways that the same information has be abstracted from place. Although these two appear to be differing epistemic positions taken in the gallery construction, from the examples that I have provided and explored in these case studies I have demonstrated that the Exploring Space gallery uses both a ‘universalised’ and ‘relational’ way of understanding other material bodies in space. However, the From the Beginning gallery relies on a relational pedagogy,
whereas the Weller Astronomy Galleries use only an abstracted ‘objective’ view to make these extra-terrestrial places known to the visitors.

5.1.2 Making nation through Outer Space

As Messeri notes, however, this place-making is not necessarily about people “settling”, or sending humans to the far reaches of Outer Space: national exercises in “empire building are not [always] about the physical acquisition of land” (Messeri, 2016, p.18). Narrating Outer Space as a location that could be visited grew out of Cold War conflicts, and as such has been understood as a type of soft power and demonstration of national excellence. Prior to the Space Race, whilst there were narratives about space, these were fictional. Some of these fictional narratives around nation can also been seen in my case study galleries, through images of books or films, and quotes from authors. Geppert summarises that Outer Space is “key to the self-image of public, governmental and technical elites, and to modernist narratives of progress” (Geppert, quoted in Millard, 2018, p.80). Not only do narratives of Outer Space and space science permeate government politics and documents (Spiller, 2015), forming a particular expression of sociotechnical imaginaries, but these nationally and temporally located expressions can be seen to be stabilised in museums at a national level (Jasanoff & Kim, 2015). The passive, ahistorical, narrative style of the Natural History Museum means that I can better critically analyse the absence of narratives (Section 5.2) than the presence of narratives, and so the examples in this section are taken from the Exploring Space gallery and Weller Astronomy Galleries.

5.1.2.1 Britain as a thought-leader

The three case study galleries that I am using were constructed at different times in the past 40 years. Exploring Space was initially installed in the mid-1980s, when the heyday of NASA exploration and Moon landings had past, but the Cold War was ongoing; and during the tail end of Britain’s colonial decline (Clark, 1994; Macdonald, 2006, 2007). Many elements of space science are constructed in the gallery, particularly in its
‘historical’ suite, as being originated in Britain even if they reached their zenith in the NASA space programme. This can be seen in two ways in the older parts of the gallery that remain unchanged since their initial installation. For instance, a reproduction of Newton’s painting occupies a whole panel close to the start of the historical teleology of space exploration:

The foundations of space flight were built on the work of Sir Isaac Newton. Every rocket works according to his Third law of Motion. This states that, ‘to every action there is an equal and opposite reaction’. (SM-ES-T64)

Elsewhere, the designs for the lunar craft are credited as being related to early work done by the British Interplanetary Society on a Lunar Spaceship:

[The British Interplanetary Society] nevertheless grew to become one of the most highly respected space research societies in the world. This 1940s design for the living quarters of a lunar lander bears a prescient resemblance to the Lunar Module used by the Apollo astronauts in the 1960s and 1970s. (SM-ES-T62)

Similar explicit links are made between William Congreve, an 19th Century British innovator and the Space Shuttle:

The first British war rockets also used Black Powder and were manufactured in the early nineteenth century by Sir William Congreve ... Many different types of solid propellant are used today. The Solid Rocket Boosters of the Space Shuttle consist largely of powdered aluminium fuel mixed with ammonium perchlorate oxidiser. [SM-ES-T69]

Language choices that position Britain as instigating work (“foundational”, “prescient resemblance”) and sentence pattern constructions that link historical British achievements directly to USA/NASA work allow both a construction of British
excellence and a mechanism to link Britain with the USA in the Cold War as allies. Furthermore, all of these constructions are in relation to British men (Congreve, Newton) – white, ‘Great Men of Science’, who are used to reinscribe a particular idea of which types of person could properly be considered a commendable British figure in this gallery space.

Built later, in the mid-2000s, the Weller Astronomy Galleries present slightly different narratives about Britain but carry through the idea of Britain as a leader in space science. A deeper time perspective still places early Britons as “the” example of people engaging with the Stars:

**About 2500 BC** Stonehenge is built. The motions of the Sun and Moon are seen as having ritual significance. [RMG-WAG-T2]

And, much like in Exploring Space, the scientists who are named to be characteristic of the British work in space science are all white ‘Great Men’ of science, including James Bradley, William Herschel (and “his brother Alexander”), Issac Newton, and John Flamsteed [RMG-WAG-T5]. However, as articulated in the previous chapter, it is important to reiterate that in the Astronomy Questions videos there is a considerably more diverse range of ‘British people’ – not only in terms of the scientists based at British institutions but also in the question-asking children. Instead of merely initiating ideas that are picked up by the USA, Britain is positioned as a key collaborative partner in international projects in the galleries – a partner on supercomputer calculations of galaxy movements, and a key player in international missions to other planets.

5.1.2.2 Changing imaginaries visible in the galleries

In thinking through the UK’s role in space science, I will draw a comparison between Gouyon’s characterisation of early displays of Friendship 7 at the Science Museum and the Exploring Space’s recent (2019) installation of the Soyuz capsule. By considering the
language and display styles, I will work to articulate a changing imaginary in the gallery space.

In the display of Friendship 7, Gouyon argues that the spacecraft displayed in the gallery constructed “space exploration ... in a manner consistent with everyday experience” (2014a). In his argument, both the accompanying material and the capsule itself were rendered “exciting ... yet ordinary, rather than emphasizing the complexities of advanced science and technology” (Gouyon, 2014a). Drawing on this idea of displaying space in the manner of the everyday, Gouyon explicitly ties the style of exhibition to:

The automobile, the epitome of twentieth-century industrial capitalism, [which] provided a key metaphorical resource for the display of another vehicle, a space capsule. (Gouyon, 2014a)

Whilst the Soyuz is arguably more of a ‘vehicle' than the Friendship 7 was – only transporting astronauts up and down to the International Space Station rather than housing them for any extended time – the ‘everyday’ presentation of the object has been lost. Although early exhibits of other capsules at the Science Museum ape the style of this first exhibit, including a step to be able to look into the craft from the side, drawing on visual and spatial narratives around automobile sales (Gouyon, 2014b), the current display of the Soyuz has a barrier with an alarm preventing individuals getting close to the capsule and there is no longer a way of stepping up to look inside (see Figure 10). Instead, digital display screens provide a 360-degree visualisation of the inside of the capsule with particular fixtures called out in detail that visitors are able to read more about. In these terms too, a strong change in imaginary can be seen:
Figure 10: Display of Soyuz Capsule in Exploring Space, Science Museum, Summer 2019 (Image credit: E. S. Armstrong).
Port Window – Has an extra outer pane that is jettisoned during the final few minutes on the return to earth

Emergency supplies – Contains essential equipment and supplies for the cosmonauts’ survival should they land or splash down a long way off course

Manual atmospheric air pump – Allows the cosmonauts to pump air into the spacecraft once landed, if power fails and they are also unable to open the hatch

Hand control for steering the spacecraft during descent in the case of automatic system failure [SM-ES-15, I6]

Instead of invoking narratives around automobiles and the everyday, these construct the spacecraft as lifesaving – positioning it as part of an emergency or disaster imaginary (e.g. Calhoun, 2008). This is seen through the lexicon of the captions, terms such as “emergency”, “survival”, “power fail”, “unable” and “automatic system failure” which express being out of control and need to remedy the situation. The hanging of the orange and white parachute up into the ceiling of the gallery also creates a “signal” for help, reiterating the idea of space travel as extreme and dangerous. While the everyday continues to be theorised as a way of getting visitors to relate to the science on display in museums (e.g. Archer et al., 2012) by making them tangible and quotidian, this move towards a more extreme imaginary could be doing work in terms of creating distance between the visitor and the science on display. I argue that this work of creating danger and emergency in a disaster narrative is tied to the presence of a British astronaut on the spacecraft in question, allowing the museum to position Tim Peake as embedded in a narrative of success over the odds, and perhaps some elements of the “superhuman” nature of this person.

I argue that this is especially the case given the recency of the change in narrative. Gouyon writes about displays in the 1960s; however, theorising about the museum in the 1990s,
Lawrence (1990) suggests that the Science Museum’s displays are reverential – which perhaps can be best seen in the display of the Moon rock from the USA moon landings as a softly lit relic in the nave of a church. Reflecting on narratives from the 1950s up to 2007, Millard suggests that one of the key roles of the astronaut in science communication is that “he is one of us and can actually tell us in everyday language with feeling what he does in space” (Millard, 2010, p.1294). Millard ascribes the British space programme’s perceived non-existence to the fact that “if the nation does not launch space rockets or send astronauts into space then it does not have a space programme” (Millard, 2010, p.1293). Perhaps then, this construction of Tim Peake – the first government-funded UK astronaut – requires a narrative of exceptionalism to reassure British citizens that the public funds have been well spent by the government (foremost in sponsoring Peake’s flight and latterly in purchasing the capsule).

Through engaging with making place, I have operationalised the idea that there is a point of reference being made in making unfamiliar places familiar and known. In reference to the epistemic act, this epistemic act of place-making is happening in reference to known places. By interrogating the materials that are included in the galleries around known places, I have demonstrated how we can understand the imaginaries that underpin these new unknowns. In particular, I have demonstrated how a narrative of nation underwrites these galleries. This national narrative takes on slightly different forms between the Weller Astronomy Galleries and the Science Museum, both in terms of their use of people and an appeal to a particular kind of nationalist paradigm.

As Spiller (2015) suggests, the nationalist paradigm, and by extension the types of narratives constructed alongside this imaginary, are not as fixed as might be expected. Instead, changeable over time, these self-perceptions of the nation are perhaps made visible through the time elapse between the conception, development and delivery of the two galleries. A conception of Britain as aligned with the United States, as collection of skilled craftspeople, feeding into the USA’s progress that I have demonstrated runs through the Exploring Space gallery, gives way to an imaginary of the UK as an
increasingly multi-ethnic space, part of a networked collection of space agencies and nation states working on space science research that can be read in the Weller Astronomy Galleries. Thus, this section of my thesis has demonstrated that by engaging in making the Outer Space familiar to visitors of the gallery, these spaces also engage in constructing or reiterating particular ideas of the nation they are developed in. Reflecting on Falk (2016) and Dawson (2019), these constructions of a particular image of Britain include those who are hegemonically enfranchised by these narratives of strong, British exceptionalism – characteristically white male Britons – and whilst there are some notable efforts toward inclusion of narratives and people that represent a diverse Britain, they are couched within the gallery centring a western vision of science. This continues to operationalise exclusion at the level of the science that is on display, rather than just the people who are.

5.1.3 Making futures in Outer Space

While galleries can be seen to be places that cement national or international positions on a project, it is also clear that “Outer Space is a crucial site for examining practices of future imagining in social terms” (Valentine et al., 2019, p.11). As such, thinking critically about the types of futures that are asserted in the galleries can be prescient in understanding the social implications of introducing futures. As I have detailed in the previous chapter, the Pioneer Plaque drawings and reproductions of Apollo astronauts in the diorama give a particular embodied idea about who could be in a space future. There are also implicit constructions around the materials included scientifically in the galleries too.

At the Science Museum there is a diorama of a future on Mars (Figure 11). With a glass pane surrounded by thick metal frame with pseudo-rivets around the box, and sitting a little higher than the head of the seven-year olds who are craning to see it on the school trip that is happening on the day I visited, this section presents a diorama of an imagined space/place on Mars. In it, a candy-striped deck chair, with bucket, space, and sun cream bottle is centre of the image, surrounded by a red landscape of sand, rocks and a painted
Figure II: "Life on Mars" display in Exploring Space, Science Museum, Summer 2019 (Image credit: E. S. Armstrong).
background against a reddish sky. At the back, on the right, is a planetary lander painted onto the wall of the diorama. Above the diorama on the wall in red lettering is printed:

**Passengers**

1. Secure your helmet before entering airlock
2. Wait for airlock light to go out before disembarking
3. Remember to take all personal articles and baggage before leaving the spaceship

Read in conjunction with images such as the NASA/JPL (n.d.) postcards from The Studio that show people holidaying on exoplanets (e.g. Messeri, 2020), this diorama is an active way of knowing the world, through imagined participation of holidaying on Mars – both in the image and in the instructions for ‘interaction’ through imagination with the image. Using the queer feminist questions articulated at the start of my thesis, I draw here on querying how social constructions have informed the construction of a scientific space; this, in turn, will contribute towards both the first and second research questions of this thesis. Whilst I read this diorama as a ‘holiday to Mars’, this is a constructed idea, informed by characterisation of what a holiday might be like. To whom or where would this deck chair belong on a holiday? In itself, the candy stripes of the chair typify a nostalgic past in Britain – not out of place in historic promotional prints I’ve seen in other museums or on social media advertising trips to the British seaside by train in the first half of the 1900s. This narrative of historic British seaside is inseparably, and imperceptibly, intertwined with western European, white, nuclear, working class or middle-class families. For me, this narrative implicates heteronormative parents, and their children – more often than not, one boy and one girl – adhering neatly to binary gendered childhood norms. In *Beyond the Bathing Belle* (2004), Harrington asserts that these posters compound a construction of heteronormative mothers or wives and their children in their composition. The diorama encourages this reading in my imagination; the mother and child are merely missing momentarily in the displayed image – leaving behind the
presence of the child’s beach essentials: a bucket, spade and that perennial parental favourite, sun cream, for when they return.

Read collectively with, in particular, the Pioneer Plaque, there are themes that stand out to me about who this exploration of space is for. Where there is an active participant in beginning our steps out into space (fictitious as they may be), they appear male. If there is more than one person, the discourse builds heteronormativity: a hegemonic family with a child; a passive, supportive (invisible) female partner. Without providing distinct, clear, alternative narratives in these gallery spaces, these instances populate the imagination with what future family structures, reproductive capabilities and astronaut sexualities might be in these new, now familiar, ‘places’ in space. Thus, public discourse, echoed in these narratives in museums systematically ‘Others’ those of minoritized sexualities and genders, who are either poorly represented or completely absent from the canonical history of space travel, and by extension not included in the “ideals” of humanity.

My (hetero)normative close readings of family or partnerships in these ‘places’ in space are reiterated and furthered in other media. The Studio’s Exoplanet Travel Bureau images, like Kepler-186f, Planet Hop from TRAPPIST-1e, and PSO J318.5-22 (NASA, 2020), suggest romantic heteronormative couple getaways in the distant cosmic future, also adopting the 1920s travel poster style. Echoing arguments about gender-norms science fiction (Pearson et al., 2011), whilst these posters advertise and imagine a future of humanity on planets where the technology to both get and be there would have to significantly more advanced than current capabilities, ideas about who might be there are firmly fixed in social constructions of the present that centre on a heteronormative couples and family. Furthermore, in headlines such as those circulated in September 2017 – “Mars mission may be all-female to avoid astronauts having sex during 1.5-year journey” (The Express Tribune, 2017) – readers are clearly meant to associate the physical act of ‘sex’ exclusively to opposite-sex relationships. Where’s the possibility of any of these women having sex with each other? Where’s the possibility that they might not have wanted to have sex with men in the first instance? Thinking of Ahmed’s queer use (2018),
we can not only see the exclusivity of astronauts being heterosexual as the default position (with only (semi)public knowledge of Sally Ride’s closeted relationship with her woman tennis partner, and Annie McClain following her 2018-19 mission on the ISS, to the contrary), but a presumption that ‘sex’ is only important/problematic in that it might lead to procreation. It’s clear what this means: women astronauts are gendered trouble in space exploration. Their (presumed) heterosexuality makes them only problematic as a biological vessel – reducing ‘sex’ to ‘reproduction’.

5.2 Out of space?

In the Teddy Bear Patriarchy, following a discussion what is present in the galleries at the American Museum of Natural History (AMNH), Haraway turns to what is not present. While the dioramas of the Museum’s Africa gallery construct white, heteropatriarchial narratives about the United States of America at the time, “the composition produces a story that is reticent, even mute, about Africa” (Haraway, 1984, p.21). Haraway turns the lens of the paper reflexively on what is not included in the dioramas to understand how these spaces exert power over the knowledge that is on display to the publics.

Likewise, the space science galleries in London emphasis on Outer Space, constructing ‘potentially meaningful places that are stages for imaginations and aspirations’ on distant planets and moons (Messeri, 2016, p.3), makes a “peaceful and tangible, domesticated yet enchanting” (Vertesi, 2015, p.230) place for public imaginations in space. This construction and work to make knowledge about places that are extra-terrestrial is done within the galleries, without dwelling on where this labour has been undertaken here on Earth – thus, overlooking ongoing conflicts about land ownership, invasion, and the value given to different knowledges. In this section, I will demonstrate this using a selection of specific instances across the galleries, revealing how, by emphasising the narratives of Outer Space, places on Earth are overlooked. Along with these I will develop arguments about the narratives that these pedagogical choices reinforce and link these with power
implications in the museum context to develop answers to the second research question of my thesis:

Question 2. By being attentive to the presence of the curated gallery space, what is absent in the gallery?

5.2.1 Mauna Kea

In 2019, an ongoing dispute between Native Hawaiians and TMT International Observatory, the multinational research organisation building the Thirty Meter Telescope, built to a crescendo, with around 15,000 protesters visiting Pu‘u Huluhulu establishing a Pu‘uhonua (place of refuge) as a long-term focus of the ongoing (as of 2020) demonstrations, leading to protesters closing the route to Mauna Kea (Goodyear-Kaʻōpua, 2020). Kahanamoku et al. (2020) centre the voices of native Hawaiians and Indigenous scientific scholars in the United States in their paper to explore the different ways Maunakea is valued. As they report:

Maunakea is a central element in the Kumulipo, a cosmological chant [sic] structured around the observations of environmental and celestial patterns. The Mauna’s position as an elder sibling to the Hawaiian people in the Kumulipo illustrates a central concept in Hawaiian culture: aloha ‘āina, or a familial love for and commitment to sustain the land, drives the foundational duty to value land. In perpetuating aloha ‘āina, Native Hawaiian well-being and the well-being of the land are interdependent; neither can exist without the other. (Kahanamoku et al., 2020, p.3)

Throughout the paper, ongoing disputes of land use revolve around questions about Indigenous rights to decide what takes place on their land, and who is granted the authority for such decisions. The authors draw a direct line from “appropriation of the personal land of the last reigning monarch of the Hawaiian Kingdom” (Kahanamoku et al.
2020, p.3) in 1893 by the United States to the ongoing uneven dynamics in Native Hawaiian homelands in 2020. This authority question comes down to questions of the value of distinct worldviews (Casumbal-Salazar, 2017) that are constructed to centre different values of “some astronomers (“mainstream science”) and those held by Native Hawaiian cultural practitioners (“Indigenous knowledge systems”)” (Kahanamoku et al., 2020, p.5). In the discourse around these protests, scientific objectivity is often asserted – linking “scientific knowledge” with “universal human knowledge”. Hawaiian scholar Iokepa Casumbal-Salazar reflected on the idea that scientific knowledge is “basic human knowledge”, exploring how this:


tacit claim to universal truth reproduces the cultural supremacy of Western science as self-evident. Here, the needs of astronomers for tall peaks in remote locations supplant the needs of Indigenous communities on whose ancestral territories these observatories are built ... “Why would anyone oppose astronomy? Why are Hawaiians standing in the way of progress?” they ask. “Can’t astronomers and Hawaiians coexist on the mountain?” These frames decontextualize the historical relations in which the TMT controversy has emerged and dehistoricize the struggle over land and resources in Hawai’i by vacating discourse on settler colonialism in favor of problematic claims to universality. When the opposition to the TMT is misrepresented as an arbitrary disregard for science, Hawaiians appear unreasonably obstinate. (Casumbal-Salazar, quoted in Kahanamoku et al., 2020, p.6)

Furthermore, these claims to shared humanity have be “indelibly marred” by the astronomical community’s “complicity with state violence” (Kahanamoku et al., 2020, p.7). These observed contentions also play out in if/when Native Hawaiian knowledge is included in astronomy on Maunakea, at an “outreach” stage (which itself is unevenly distributed around the islands) rather than through reciprocal dialogues at inception. Moreover, these debates that position Indigenous Knowledge systems as antithetical to
Figure 12: Image of western astronomers in Hawaii, taken from the Astronomy Explores Gallery, Summer 2019 (Image credit: E. S. Armstrong).

Transit of Venus

When Venus passes (transits) between the Sun and the Earth, the sunlight we receive is very slightly dimmed.

By recording and timing these events across the world, astronomers calculated the precise distance from the Earth to the Sun.

Figure 13: Image of “UK Infrared Telescope in Hawaii”. Still from Astronomy Questions, Royal Observatory Greenwich, Summer 2019 (Image credit: E. S. Armstrong).
science, marginalise, and silence Indigenous astronomers, who are by and large in junior positions and therefore less able to speak out against senior faculty who continue to position the two identities as binary and opposed (Kahanamoku et al., 2020; Goodyear-Kaʻōpua, 2020). While Kahanamoku et al. (2020) assert that the dynamic between the astronomical community and Native Hawaiians has been “unbalanced and prioritised research since the constructions of the first telescopes in the late 1960s” (p.3), I would argue that in the space science galleries I am studying, these narratives constructing this astronomical work as “inherently non-violent and in the common interest of humanity” (p.3) predate the building of fixed observatories, and are evidenced in galleries as a way of securing, maintaining and perpetuating the objectivity and apoliticality of the act of observation.

Since the 1800s, Pacific Islands, including the Hawaiian archipelago, have been used by European and western scientists to gather astronomical data. Particularly notable in the history of science is these Pacific destinations’ use in observing the transits of planets – the journey of a planet between a star and the Earth, in front of the star, visible from Earth. These positions on Pacific Islands are valued by European astronomers, as they allow the astronomers to get two different sets of data, as far apart on the Earth’s surface as possible in order to calculate the lengths of the sides of the triangle made by the two data points and the star. It should be noted that, for instance, scientists of the Russian Empire were able to take similar data from various points on the landmass of Russia (see, for example, Bucher, 2013). Cook’s journey of 1769 to Tahiti (recounted in, for example, Stearn, 1969) ostensibly facilitated collection data on the transit of Venus as organised by the Royal Society. The journey, however, was also charged with finding and returning items of potential economic value for the then growing British Empire. Indeed, British expeditions for transit observations continued on into the 20th Century, and are included in the Royal Observatory Greenwich galleries of this thesis, for example in a facsimile of The Times from 8th November 1919 documenting “the discussion which took place at the rooms of the Royal Society on Thursday afternoon on the results of the British expedition to Brazil to observe the eclipse of the sun [sic] on May 29” [ROG-WAG-AQ-A13].
Elsewhere in the Astronomy Explores gallery, there are also several objects associated specifically with Hawai’i. A display as part of the interactive gallery Astronomy Explores on transits talks about Hawai’i as a base of observations for the transit of Venus in 1874. The photograph (from Cambridge University Library, Figure 12) that accompanies this discussion of a transit depicts a number of white men working on a telescope. The exact location, nature of these researchers nor who they are is specified in the image caption:

Astronomers at Station B, Honolulu, in Hawaii [sic], preparing to observe the 1874 transit of Venus, only the fourth ever recorded. (ROG-WAG-AE-T11)

Below this, there is a “Reproduction of a photographic test plate” (Object number PR0158) which was:

To record the 1874 transit of Venus, astronomers were trained to use a new type of camera by practising with test plates. (ROG-WAG, A3)

Finally, in the videos of contemporary astronomy in the Astronomy Inspires gallery, there is a small bit of detail about a telescope that was commissioned by the UK (Figure 13). The UK Infrared Telescope was owned and run by the UK Science and Technology Facilities Council until 2014, when it was taken over to be funded and run by NASA and a scientific cooperation of Lockheed Martin Advanced Technology Center, the University of Hawai’i, and the U. S. Naval Observatory. In the gallery it is described as delivering data:

The UK Infrared Telescope in Hawaii can peer through the hot dust in a star nursery like the Orion nebula. (ROG-WAG-AI-V5)

In the first two instances, the use of Hawai’i as a site for observations is historicised – through the use the test plate from 1874 and through the image of astronomers taking the data that accompanies it. The caption on the plaque does not draw the discussion to the
present, by suggesting that research is still happening in the same site as of 2019. While the video does indicate that research is ongoing, as can be seen in the stills of the video that is about the UK IR Telescope, there are no people doing the work, and the telescope is not more broadly situated in the landscape of Maunakea either through the framing of the image or the voice over delivered by Professor Lucie Green.

Modlin Jr et al. posit a phenomenon of “affective inequality” in museums (Modlin Jr et al., 2011, p.5); that the empathetic investment by visitors to a gallery is unevenly distributed between different subjects created in a gallery space based on their construction in the gallery. By creating geographical separation, the separation by history, and by not including voices of those to whom the Mauna also has significance, Hawai‘i as affectively distanced from the visitors to the gallery. This leads to an ideological assertion (Katriel, 1993) about which narrative and knowledge that are valuable, exerted through the curatorial authority of the galleries in ordering knowledge and prioritising the worldview that asserts and naturalises western astronomical knowledge as unique and of universal importance (Anderson & Smith, 2001).

5.2.2 Woomera and British rockets

Similarly, the Science Museum features a large section on the Black Arrow R4, which hangs in the ceiling of the gallery, a UK rocket intended to have been launched from Woomera in 1971. A forerunner of the R4, the R3 placed the Prospero satellite into orbit (Sketch et al., 1975). Drawing on Hill’s recollections of the event, Millard has described the final launch of the programme as follows:

On the cool, fresh South Australian morning of 28 October 1971, the United Kingdom’s Black Arrow R3 rocket rose from its pad and climbed steadily into a clear blue sky. (Millard, 2018, p.79)
After this final launch, Britain’s nascent space programme of Black Arrow rockets, born from the Blue Steel missiles, was all but cancelled, meaning the R4 was never launched. As I have argued earlier in this chapter, making places in Outer Space can be an action that asserts national narratives; thus, it is perhaps unsurprising that many academic texts that relate the cancellation of this space programme focus on the impact on scientists in the UK, on national identity, and on international politics (e.g. Harvey, 2000; Hill, 2001; MacDonald, 2006, 2007; Moore, 2013).

However, in both the cases of constructing national identity and in describing the launch, the location of the launch site is under-explored as a ‘place’ that bears importance in Outer Space discourse. The launch of the Black Arrow rockets took place at a test site in Woomera, Australia, which was used instead of a launch from Europe (Hill, 2001; Morton, 1989). ‘Woomera’ connotes not only a town north-west of Adelaide in Australia but also the associated test range (or rocket range) that covers around 122,000 km$^2$ (Defence Regulation r58, 2016). Having been used as a rocket launch range in the 1960s-70s, Woomera is currently being redeveloped into a place for national defence in Australia$^2$. Woomera, created in 1947 in Southern Australia, was chosen as a suitable location for launches because of its perceived emptiness (Gorman, 2005; Hill, 2001).

Much like occupation of ‘empty’ land for nuclear testing sites in Maralinga, Australia (Morton, 1989; Starkey, 2004, in Gorman, 2005) and selection of the Karoo in South Africa for the Square Kilometer Array (Parkington et al., 2019, Walker et al. 2019), the lands chosen are often “dry and sparsely populated, but ... not empty” (Parkington et al., 2019, p.729), meaning that “technological progress benefits those in positions of power at the detriment of those at the extremities of society” (Hall, 2018, p.153). In the case of Woomera, land that constituted the Central Aborigines Reserve, looked after by Indigenous peoples, particularly the Kokatha and Pitjantjatjara peoples, was occupied to

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2 In itself indicative of the links between space and defence that are visibilised elsewhere in relation to particular nations
create the town by displacing those already there. In an ‘effort’ to acknowledge the land’s heritage, the name ‘Woomera’ itself comes from the Dharug term of the Eora people (who are based in the Sydney area), for a spear-throwing implement that extends the range of a thrown spear – although it is “not a local word” (Gorman, 2005, p.95) to the area where the town is situated. Much like the Karoo, Woomera was selected because it was perceived as “remote, arid and devoid of people” (Gorman, 2005, p.94), and, like Maunakea, the knowledge systems and relations to the land of peoples who lived there were perceived as being less important than ‘universal’ claims to land use for western scientific and defence operations.

In the Exploring Space Gallery when the Black Arrow is described, the largest panel that is clearly linked with the rocket hanging in the ceiling of the gallery omits the launch location:

The Black Arrow was Britain’s first, and to date, only satellite launch vehicle. Its design was based on the Black Knight test missile. It successfully launched the X3 satellite on October 28, 1971.

Black Arrow was a three stage rocket capable of placing a 145kg [sic] into a low Earth orbit. Its performance was similar to the United State’s [sic] Scout rocket (displayed nearby). The first two stages used liquid propellants, the third stage used a solid propellant motor. [SM-ES-T58, emphasis in the original]

Further down the gallery, there is a similar omission of the location of launch, despite including the (British) location of the satellite’s development:

X3 (Prospero) Satellite
Flight Space
Britain ran the X-series during the 1970s to test prototype satellite technologies in orbit. X3 was launched as the Prospero satellite by Black Arrow R3 on October 28, 1971. It carried experiments on thermal control surfaces, solar cells and various
electronic components, as well as a micrometeoroid detector developed by Birmingham University. X3 had a central box structure made of four sheets of aluminium honeycomb. Eight outer panels were added and hinged at their tops so that access to internal equipment was easily obtained. [SM-ES-T46]

In both cases, the explanatory text is accompanied by ‘Technical Information’ (a focus on numeric facts) and ‘Launch Record’, which comprise a significant quantity of data, including dates, weights and details of the mechanics, but is silent on the location of these launches. However, close to a model of the Black Knight rocket, away from the first Black Arrow rocket panel text above (see map in Appendix C), where the Black Knight had been mentioned, is a 1:8 model of the Black Knight. Here one reads that “between 1958 and 1965 22 Black Knights were successfully launched from Woomera in South Australia” [SM-ES-T51], and on an adjacent panel in smaller text:

The launches of all Black Knight test missiles and Black Arrow rockets were carried out in South Australia from Area 5 of the Weapons Range Establishment at Woomera. Black Knight 13 is shown on the left in the foreground with the two-staged Black Knight 14 just visible behind. Black Arrow R-1 (launched March 4, 1970, as a test vehicle for R-3, the rocket which orbited the Prospero satellite) is shown on the right. [SM-ES-T54]

This narrative runs down the South side of the Exploring Space Galley, developed to be walked through chronologically from the front of the museum into the gallery, meaning that the spatial movement would involve passing the larger Black Arrow label before reaching the Black Knight/Black Arrow panel, this making it less clear to the visitor that these were sequential developments. In returning to the affective inequality that is constructed with regards to prioritising within these programmes, the words used to describe national affiliations within these four panels are as likely to be describing ‘Britain’ or a location in the UK (Birmingham University) as to reference Woomera. Furthermore, Modlin Jr et al. (2011) modulate affective inequality to understand that it is
not enough to count the number of times words are mentioned or positioned; it is also important to consider the ways the terms and ideas are characterised. In this instance, the discussion of ‘Britain’ happens on panel texts that are well lit and centrally positioned in the galleries that visitors walk by even on their way through Exploring Space. By contrast, the references to Woomera appear in smaller texts, on panels that are less easily visible (at an angle to the vertical, with a shiny surface that makes reading the white text harder than the matt surface of the two larger panels), and are positioned ‘tucked behind’ the large rocket engines that take visual focus of the south side of the gallery. Thus, in comparing within the set of data that are on the British rockets in Australia, we find a diminished engagement with mentioning the use of this Indigenous land.

Moreover, the notable lack of information on these large panels also appears in contrast to other sections on the Exploring Space Gallery, where geographic locations of developments and launches of rockets are detailed. For example, texts detail that:

In 1936, work started on a vast rocketry complex at Peenemünde on the Baltic coast. There, over the next seven years, between £1 billion and £2 billion were spent developing the ‘Aggregate-4’ missile, later named the V-2. When allied aircraft bombed the site in 1943, missile production moved to an underground facility inj [sic] the Hartz Mountains and was run by the SS [SM-ES-T60]

Allied bombing prevented V-2 missile launches from fixed coastal sites and all missiles were fired from mobile units travelling around occupied Holland [SM-ES-T59]

The German army developed many other types of missiles at Peenemünde [SM-ES-T61]

After a four-hour descent on 18 June 2016, the craft parachuted down onto the plains of Kazakhstan, bringing the crew safely home [SM-ES-T42]
While the warping of space-time in this way appears inconceivable [as done in the USS Enterprise from Star Trek], the fusion process employed is less so. The generation of energy by fusion is actively researched at centres like the Joint European Torus (JET) at Culham in the UK. Antimatter is produced in small amounts at Fermi Labs in the US. [SM-ES-T35]

These texts (even about fictional spacecraft) once again are dominated by references to European locations (Holland, Peenemünde, Culham) over and above other launch sites around the world. Whilst, for instance, the gallery contains models of the Ariane IV and Ariane V, the launch of these rockets in French Guiana by the European Space Agency (as documented by, for example, Redfield, 2000) are unremarked upon in the gallery space [SM-ES-A79, A80]. These models are likely to have been commissioned to sit alongside the many other models noted in early exhibitions on space science at the science museum (Gouyon, 2014a, 2014b; Millard, 2010, Morgan, 2019) and take their place next to, amongst others, models of the Space Shuttle; however, details about geographies of launch remain unacknowledged.

5.2.3 Collecting resources

The positioning of the research at Maunakea, Woomera, and French Guiana speaks to a larger trend within a history of science ‘exploration’, of considering lands used in the service of western science to be ‘terra nullis’. This invocation of ‘terra nullis’ (literally, ‘nobody’s land’ or empty land) has taken place in many sites that are now utilised for space science research. Not touched on in this thesis are the Antarctic (Collis, 2017; Praet & Salazar 2017; Spiller, 2015), the Gobi (Meszyński & Józefowicz, 2015) and the Atacama Desert (Messeri, 2015), all of which are also places central to space science work as ground-based research sites, analogous to extra-terrestrial landscapes, or places for sample collection – par excellence for meteorites, and feature in the galleries under study. Furthermore, by asserting emptiness, there is the implication that there is no one in the
location who would have knowledge or might look for the expertise to develop knowledge in the subject field in that geographical location.

In the From the Beginning Gallery, the SaU005 Martian meteorite is on display (Figure 14, [NHM-FTB-A2]), one of two rocks from beyond the terrestrial landscape in this gallery. This meteorite was collected in Oman, and is now in the collections of the Natural History Museum, along with many other specimens from the region elsewhere in the Museum’s galleries. Oman, after Antartica, has the largest naturally occurring instances of Martian and Lunar meteorites in the world. Al-Kathiri et al. (2005) assert that the landscape and climate are the reasons for this. The surface in the area is made of plains of flat tertiary limestone with little vegetation, and the Lunar and Martian meteorites are found at high elevations in the area. Additionally, in these areas, temperatures are high (in excess of 50 °C in the summer) and precipitation is low (below 10 cm a year) (Al-Kathiri, 2005). This means that, unlike most other places on Earth, there is little climate weathering on the rocks that fall in this area; so, much like the Moon or Mars, the rocks remain the same for extended periods of time.

However, evidence suggests that the vast majority of falls in the area are collected by foreign institutions, such as the Natural History Museum, sold off by institutions in Oman, or stolen and illegally smuggled out of the country to be sold later elsewhere (Al-Kathiri, 2006). Oman, for an extended period from the 18th to the 20th centuries, was subjected to de facto colonisation by Britain, making it a place where the British maintained trading routes, access to markets for buying and selling enslaved African people, and, during the 20th century, access to oil in the interior of the country (Owtram, 2016; Wilkinson, 1971). This proxy-colonisation allowed scientists and explorers access on collecting missions to populate museums such as the Natural History Museum. For example, Bertram Thomas’ arrived in Oman in the 1920s furnished with:
Figure 14: SaU005 Martian meteorite, displayed in From the Beginning at the Natural History Museum, Summer 2019 (Image credit: E. S. Armstrong).
prismatic compass, aneroids and a hydrometer, sextant, artificial horizon and chronometers, surgical instruments for skinning, killing and preserving bottles, a Winchester rifle and a butterfly net, cranial callipers, and two cameras, and collected specimens of water, sand, fossils and animals (Al-Hajri, 2006, pp.201-202)

demonstrating intent for natural history collection, and was later documented as having:

collected two eagle’s eggs from a nest, in addition to the five hundred and ninety specimens of reptiles and insects he collected during this expedition; all these specimens were taken to the Natural History Museum in London. (Al-Hajri, 2006, p.202)

Whilst it is unlikely the Martian meteorite on display is from this collecting mission, I include Thomas to demonstrate a more general attitude towards taking natural and cultural materials from Oman to Britain. As is argued by Al-Hajri:

One has the right to raise a question about the ethics or the morality of such actions … Some critics have considered these collections as ‘stolen’, ‘looted’ and ‘plundered’ on the grounds that they were taken without permission and without any intention of returning them … Likewise Raby argues that some European travellers were ‘plant-hunters’ and regarded the rest of the world as ‘an extended farm’ bringing back to England the most valuable species of transplant. (Al-Hajri, 2006, p.202)

Drawing out analysis of why these materials – these rocks and plants and animal specimens – come to be in the Natural History Museum has opened a new avenue for critical approaches to the collections on space science. This example of systematic removal of a natural resource not only treats the rocks as capital that can be moved around and monetised, but has also and continues to prevent the development of specialisation of
study of these extra-terrestrial rocks in the country they are found (Al-Kathiri, 2006, p.3). As Tuck and Yang (2012) detail, external colonialism (of which this ‘collecting’ is an example) recasts “all things ... as ‘natural resources’ – bodies and earth for war, bodies and earth for chattel” (p.4). This natural resource is a “most important concern” covering “land/water/air/subterranean earth” (p.5), often simply referred to as ‘land’.

Thus, through these past three sections on Maunakea, Woomera and Oman, I have demonstrated how using queer feminist questions about what counts as ‘science’ and who (gendered or otherwise) does it to answer my second research question about what or who may be absent in the galleries; I have revealed in detail a western colonial construction of ‘science’ that marginalises and silences particular knowledges and histories of space science to prioritise western science as universal knowledge.

5.2.4 Terra nullis?

Concepts such as terra nullis are not without history and continued development, both in literary and visual modes. Perhaps a way to see the bounding of terra nullis is to compare it to terra communis (land owned collectively by humanity) – a tension that evokes different imaginaries about the roles and responsibilities towards places such as Outer Space or Antarctica (Collis, 2017). While terra communis is read into imaginaries about preservation, collective responsibility and pristine land, the invocation of terra nullis as a concept brings to the fore worldviews associated with ‘empty land’ and draws on languages of progress and, alongside that, imperialist expansionism (van Houtum & Bueno Lacy, 2016). Chief amongst these ideas is the imperialist notion of limitless expansion into a space, creating a place or a world that lies in front, a world not yet known, based more in imagination and aspirations than reality (Kristof, 1959). Turner, in *The Significance of the Frontier in American History*, describes western America as “an area of free land”, creating a distinction between land “civilised” by settler colonists, and that land “not civilised” – but occupied by Indigenous Americans – as ‘empty’ land fit for
forceful colonisation (Turner, 1893). This frontier thesis is continued through American history, and is:

present as vindication for the seizure and control ... [of land] whose emptiness in physical or ideological terms required – or at least justifies – the kind of management that would be unacceptable in populated lands (van Houtum & Bueno Lacy, 2016, p.3)

creating space as the ultimate empty space, the best ‘final frontier’. Thus, thinking about *terra nullis* as being adjacent to the language of wilderness, or land in waiting for taming, positions Outer Space or empty space as close to the language and imaginaries of the American frontiers. As van Houtum and Bueno Lacy accurately surmise, the frontier, like many other concepts, can ultimately be seen as a expression of “political implications of ... power” (van Houtum & Lacy, 2016, p.3). It follows from this that scholars have analysed and understood how frontier imaginaries have been made through American space science. In 1800s America, the language of wilderness had been operationalised by campaigners who “sought to exclude poor and native populations” (Chatterjee, 2019, Section 2) from national parks and zoos, to keep the wild ‘pristine’. Later, in the 1945 report *Science: The Endless Frontier*, characterising Americans as natural physical and metaphorical pioneers on the frontier allowed the author to suggest that “the pioneer spirit is still vigorous within this nation [and] Science offers a largely unexplored hinterland from the pioneer who has the tools for his task” (Bush, quoted in Spiller, 2016, p.9). Over time, this same narrative of the American nation as pioneers, protected by white masculinity as a timeless virtue, justifying global leadership, was projected into space as a motivation for exploration of Outer Space, narrativizing:

American history [as] a straight line, a vector of inevitability and manifest destiny linking the westward expansion of Anglo-Americans directly to the exploration and colonization of space. (Limerick, quoted in Billings, 2007, p.487)
Falling in line with former theorisation of the frontier in relation to “civilised” Americans – land articulated around gold and riches – this new language of “final frontiers” that permeated fictional and factual discourse also fell in line by creating a “new world [that] is always posited as a world of riches waiting to be exploited”, by making sure Outer Space, too, was “couched in the discourse of wealth” (Gunkel, 2001, p.38). Indeed, through drawing linguistic parallels with frontier narratives, those working in space science can mark themselves and their work as:

exemplars of the progressive spirit, which, in its association with the concept of manifest destiny, marks outer space as a territory that those exhibiting ‘the best human traits’ can claim for themselves. (Shaw, 2008, p.105)

Kessler asserts that this ongoing work for figuring Outer Space to be an extension of the American pioneer narrative happens through the colouration and presentation of Hubble Space Telescope images, drawing on the visual semantic lexicon of sublime representations of the western America (by, for example, Ansel Adams) as well as colour palettes where the “colours are dynamic, and the yellowish orange clouds vibrate against the bluish green background” (Kessler, 2011, p.69).

However, Vertesi narrows this visual reference further, observing during her ethnography of Mars planetary scientists that the images created for public distribution share the “primary characteristic in framing [the images as part of] a genre broadly classifiable as that of the American frontier” (Vertesi, 2015, p.228), through visual semiotic choices that draw on familiar images of “wagon wheels on a pioneer trail” or “heading off into the sunset like a cowboy in a Western movie” (Vertesi, 2015, p.228).

Unlike Kessler, however, Vertesi asserts that images also draw on the:

picturesque convention in eighteen-century landscape painting ... arranging the landscape around an observer who is embedded within it ... [such that the] viewer is not overwhelmed by their surroundings such that the view is terrible, awesome,
or emotional (as in the sublime); nor are they observing from an impossible vantage point. Instead, they are grounded and embedded in a scene that is peaceful and tangible, domesticated yet enchanting, occurring at a precious place and time. (Vertesi, 2015, pp.229-230)

In Seeing like a Rover, Vertesi (2015) goes on to suggest that this work of making the images familiar makes them pictures that are participatory:

Transforming Mars into a vision you would see if you were there invites the viewer to step into the frame, into the rover’s tracks so often visible in the science. This is not a view from nowhere or a God’s eye view. Instead the viewer is clearly situated on Mars, alongside the robot. Nor is it especially a rover’s-eye view ... these images present a view oriented toward the human observer (Vertesi, 2015, p.229)

or, as Kessler sees the framing of these images, “making the metaphor of a picture as a window to another world” (Kessler, 2011, p.62). In both Kessler’s and Vertesi’s reading of the Hubble and Mars images, the images are not produced as scientific tools, nor as images for scientific analysis, but are instead theorised as a way of getting “the public” to be aware and enthusiastic about the mission work – to help US taxpayers for fund the missions see a “tangible result” (Vertesi, 2015, p.232) for their money, helping the public imagine what “you would see if you were standing on Mars” (Vertesi, 2015, p.232). In this act of creating the images, these aspects of space are drawn as “the new American frontier” (Vertesi, 2015, p.232) – (re)asserting a nationalist and nation-state agenda in space science work, through making these into places viewers are familiar with.

In all three galleries this action of drawing the images of space to be “as you would see it” is visible through images that are taken as if from the surface of the solar body in service of “making place” in the gallery, as I have covered in Section 5.1.2. Whilst the analysis I provided in that section allows us to understand these images as part of making these far-
off places appear habitable, I return to these images to read them again in making this visible through the lens of the American frontier, or the picturesque. In doing so, the images dovetail with dominating narratives about NASA (and by extension the USA as the people who do space), creating, as Limerick explored, a teleology for the visiting London public about who Outer Space and space science is for.

Many of the images that Kessler specifically draws attention to are included in both Exploring Space and the Weller Astronomy Galleries. In each case, although the images used are the ‘pretty pictures’ created by the Space Science Institute’s Hubble Heritage Project (Kessler, 2011), the gallery texts and their positions attempt to wrestle these images into being scientific data, through captions and adjacency to instrumentation. In Exploring Space, the images are on a digital display screen that is below a model of Hubble, and next to a panel describing the process of doing science with Hubble images. The text on the digital display reads, for example:

The Keyhole nebula. The high resolution of this Hubble image shows numerous small dark globules that may be in the process of collapsing to form new stars

M51 – the Whirlpool Galaxy. The red-coloured star clusters are forming under the gravitational influence of the nearby NGC 5195 galaxy. [SM-ES-I2]

In Astronomy Explores, the Whirlpool Galaxy and the Eagle Nebula are used to explore how data from telescopes is interpreted:

These instruments produce a grid of numbers which astronomers convert to colours to make an image. These ‘false-colour’ images help us to picture the universe in other wavelengths (Whirlpool Galaxy style image, [RMG-AE-T6])
These images show the Eagle nebula in infrared light (left) and in visible light (right). The infrared image reveals that stars that in the visible image are hidden inside or behind the huge pillars of gas and dust [RMG-AE-T6]

Although Kessler suggested that the image creators at the Hubble Heritage Project “emphasised aesthetics over pedagogy” (Kessler, 2011, p.64), the aesthetics here are subverted to be used as pedagogy, teaching visitors to read these familiar, popularly circulated ‘pretty pictures’ as scientific, where colour choices (e.g. “red coloured stars” and “small dark globules”) are ascribed to ‘real’ scientific phenomena. Even when in Astronomy Explores the use of these images is developed further to help visitors critically engage with the way the images are presented, there is not significant development of understanding that these are anaesthetised, constructed images and not the scientific data (although, arguably, images used in science research are also constructed). This sleight of hand, treating what are considered ‘pictures’ as ‘data’ in the gallery, normalises and naturalised the aesthetic choices that have been made in the construction of the images, hiding the roots of the aesthetic choices that have been detailed above.

Whilst this may appear speculative, I argue that looking at historic representation of planets and Outer Space helps us develop an understanding of the ways contemporary images are shaped by contemporary imaginaries. Dark lines on the surface of Mars observed by Schiaparelli in 1877 sparked interest that Mars might be populated by efficient, superior Martian industrialists building canals across Mars, as proposed by Lowell (e.g. Lowell, 1895). The projection of this canal-building intelligent life reflected a push for large infrastructure happening in the West at the time and so the maps, books and associated media reflected these aspirant ambitions back in a far-away world (Nall, 2019). Whilst this is no longer how we ‘make place’ on Mars – images from high definition cameras on rovers now provide us with this – we can still see these ideas collected in the Exploring Space Gallery:
Signs of life?

People have long wondered whether there is life on Mars. The Red Planet has been the subject of countless stories and films, and since the 1960s the target of many space missions to try and find out whether life may exist there – or have done so in the past [SM-ES-II].

This is accompanied by an illustration of “Camille Flammarion’s impression of canals on Mars, 1884”. Much like Hubble images, these drawings were based on data at the time, which were then interpreted through an epistemic lens of their collectors, reflecting their worldview back to us when we look at these images in a gallery space now. It may not be clear that the visual narratives, texts and spaces are feeding into a particular idea of what space ‘looks like’; we certainly have to ‘draw’ it for it to look like the end point of American colonisation of ‘the final frontier’ (Vertesi, 2015), and ‘draw’ it we have.

So, whilst there is less explicit language around colonisation or the final frontier in these galleries, there are moments in this section on Mars where these sentiments appear in the cracks, under titles such as “Viking invasion”, or suggesting that visitors could imagine “Hunting Martians” [SM-ES-II]. Positioned next to the imagined canals of Victorian industrialists, where I have highlighted how a worldview informs the construction of the images and imaginaries, it is clear that this imaginary of Mars involves neo-colonial exploits in order to gain scientific knowledge about the planet. Whilst only select examples are given here, these narratives are writ large in Elon Musk’s construction of Space X, and can be seen in planetary science titles such as:

Why it is ‘easy’ to colonise the Universe (for a talk, given at UCL, 2020)

Evaluating mineral resources on Mars for exploration and colonization (for a postdoc project at U.S. Geological Survey, 2020)
Examples such as these reinscribe a particular attitude as to who should be part of these planetary futures, perhaps read against roles in historic colonisation of land, bodies and minds. As such in literature, including *The future may be bleak, but it’s not black*, contemporary futurisms manifest the wilful blindness of white racism (Davis, 1983). Thus, these narratives perpetuate colonial violence, confirming Kilgore’s assertion that science fiction futurist narratives “[do] not expect blacks to have any influence over their own or human destiny” (Kilgore, 2003, p.13). Relatedly, Kilgore, in 2003 before the rise of a private space sector, noted how historic science fictions writers such as:

> von Braun, Ley, Clarke and Heinlein ... promoted the space future as the next step in human evolution, they represented only a small slice of the human race as fit explorers of the space frontier. A scientific and engineering elite, often in uniform and nearly always organised in military-style hierarchies, was their ideal of the space cadet. (Kilgore, 2003, p.228)

I believe that we can think of individuals who propose contemporary stories about the planetary futures as continuing this tradition of white, colonising humans as best fit for exploration of the imagined ‘space frontier’. I have demonstrated that the narratives of empty land, and the associated invocations of the frontier of Outer Space, are explicitly couched in narratives of white imperial expansionism in general, and in the narratives around the American West in particular, eliding, eliminating and silencing the experiences and the voices of Indigenous peoples. I have further shown how imagery that draws from the picturesque and the sublime, invoking ideas of control and dominion over land and the awe and wondering respectively, is in turn linked with the American West. Finally, in this section, I have shown that images of this style permeate the galleries that are case studies in this thesis.

To conclude, I want to draw attention to Whyte’s ongoing assertion that for many Indigenous people, the violent and destabilizing social, environmental and cultural impacts of colonialism have already passed (2018). These may be climate change impacts
to the landscape or devastation of particular ways of life, but they are the impact of settler colonialism, and they are not a future nor an imaginary, but a history and certainty. Looking at images that draw so strongly on the visual semiotics and narrative of a movement that impacted so harshly on Indigenous communities, not only in North America but also elsewhere as a result of imperial undertakings, projects particular narratives about who is “right” in space, even without people in those landscapes. Thus, the absence of significant counter narratives that might detail non-American and non-frontier narratives within the gallery space is a part of the creation and perpetuation of colonial narratives around space science in science museums.

5.2.5 India, and the construction of British passivity

Much as settler colonist Americans benefited from their expansion to the West Coast, the British Imperial project gained greatly from the colonising of India at the cost of peoples who already occupied that land. Whilst many discussions about decolonising and critical approaches to the British-Indian relationship discuss, for example, Tipu’s Tiger at the Victoria and Albert Museum (Procter, 2020; Qureshi, 2017), art and decorative objects were not the only items looted through colonial violence.

As I enter the Exploring Space gallery from the front of the museum, there is a model of a person dressed in military uniform on the left. The first time I fully spent time considering this person, I noted that he was one of only three model figures in the Exploring Space gallery, the others being the first white American men on the Moon. I assumed therefore he was of great historical importance, especially as, above his head, was a model of Sputnik, the first satellite to orbit the Earth (Figure 15). Clearly many others do too – during my fieldwork there are people looking and discussing, along with children questioning who this is. His clothes date him to before Sputnik’s time – the military brocade fits the 1750s more than the 1950s – but the positioning links this model and their achievement to the monumental move into Outer Space that was the Sputnik mission.
After the British attack on 2nd May 1799 of Srirangapatna the winning soldiers sacked the town. Alongside taking with them objects such as Tipu’s Tiger which now resides across
Figure 15: Model of William Congreve in Exploring Space at the Science Museum, Summer 2019 (Image credit: E. S. Armstrong).
Exhibition Road, the troops stole unused supplies of rockets that had been used against the British, and the Fathul Mujahidin, a guide for soldiers commissioned by Tipu Sultan (son of Hyder Ali). Published in the 1790s, the book detailed the military uses and applications of the rockets (Van Riper 2004). In a case around the area where Congreve’s model is found, are examples of models of early rockets:

Indian War Rocket c. 1790 (Replica) [Object Number: 1986-465]

Rockets like this were fired in great numbers at British and French troops during the Maratha wars in the late eighteenth century. They had a substantial range of over 940 m. This was due to their iron casing that allowed greater burning pressures than those of the cardboard-cased European ones [SM-ES-T66 and A145]

Elsewhere, nearby, the description text for the case alludes to the idea that Congreve’s work derives from that of the opposing troops:

The first British war rockets also used Black Powder and were manufactured in the early nineteenth century by Sir William Congreve. His designs evolved from those of Hydar Ali, Prince of Mysor, whose troops fired rockets at the British army in the 1790s. [SM-ES-T66]

Thinking through who is seen as doing science, I will argue that the agency of creation or development is carefully moved by these texts from technological innovators in Srirangapatna to the British colonists co-opting the knowledge. It is Congreve who is credited with progress and development such that by 1823 he able to hold “the first rocket patent to be taken out in Britain” [SM-ES-T66]. To get to the point where the rockets looted were so notably better than the “cardboard-cased European ones” (SM-ES-T66), significant innovation, development and progress had also been made – but the work of the military of Mysore is overlooked in favour of a British military man. This construction
ties back to my discussion earlier in this Chapter about the creation of space science as an exercise of soft power in positioning the nation. Here, this narrative allows British Imperialists to usurp their colonial subjects as the leaders of development in rocketry. The closing link in this section of the gallery is made between the early rocket developments, and pinnacles of rocketry achievement, to “the USSR’s 1957 R7 rocket that launched Sputnik” that “shared a common means of propulsion” [SM-ES-T69] and to “[t]he Solid Rocket Boosters of the Space Shuttle” sharing “solid propellant” as their means of getting to space [SM-ES-T69].

This teleology of the origins of rocketry allows the British to be situated at the source of these innovations. The gallery text, in a single sentence, includes the possibility that these rockets may not even have been the first iteration:

The first rockets, through to have been developed in tenth century China, burned gunpowder, a blend of sulphur, charcoal and saltpetre, often called Black Powder. The first British war rockets also used Black Powder and were manufactured in the early nineteenth century (SM-ES-T66)

The narrative jumps of the use of this innovation skip 700 years of developments, cross-cultural transmission of knowledge through Chinese dynasties, Islamic scholars and Indian Sultanates as well as other travels of knowledge about gunpowder (itself, a part of a plural technological historiography (Andrade, 2017)). Instead, it too positions the British as the ‘good’ and talented craftspeople able to innovate and improve the technology.

Approaching these texts from a slightly different critical question, I argue that the use of language around who is allowed to do science also positions the British nation as passive, whereas those whom the British had as their oppositions are depicted as being the violent perpetrators. In the very first example text I presented, we see that “Rockets like this were fired in great numbers at British ... troops”, during battles with Hydar Ali and Tipu Sultan, “whose troops fired rockets at the British army in the 1790s”. Further round the section
that depicts a chronological progress of rocketry, the British are also seen almost exclusively in the position of being attacked by the German V2 rockets, without significant narratives of being aggressors in their own right:

The [V2] missiles travelled at supersonic speed and targets received no warning of the impending impact. (SM-ES-T59)

The aftermath of a V-2 strike at Smithfield Market in London, March 9, 1945. BBC Hulton Picture Library Science and Society Picture Library (SM-ES-T59 and A122)

*Image of Major-General Dornberger and Wernher von Braun read a telegram of congratulations after the first successful launch of an A-4 missile in October, 1942. Deutsches Museum Science and Society Picture Library* (Italics in the original, SM-ES-T61)

In these labels discussing the Second World War, any aggressor moves are written about under the “Allies”. Whilst Britain was a member of the Allied forces, the Exploring Space gallery is considerably less explicit about who is doing these attacks and, by extension, the role of British troops in the War. These two instances, read together, demonstrate a positioning of the British as being removed from aggressor positions in conflict. Both cases in the gallery offer examples of language of active violence (firing rockets, sending missiles, the shock of attack, the devastation caused) against the British troops and nation. Read as a reflection on identities, these texts work to construct Indians and Germans as the aggressors and ‘Other’ in the gallery space, a message that can be internalised as the narrative around innovations in these countries, as there is no other challenge to these narratives in the Exploring Space Gallery.

While not part of the galleries that I am studying for this thesis, I would like to bring in a temporary exhibition that was hosted at the Science Museum in 2017-8 – *Illuminating*
India: 5000 Years of Science and Innovation (2017). One section of the exhibition described Indian innovations, but this story of development was notably absent there too–possibly so as not to provide discordant narratives across the museum. However, this small exhibition did have some narratives about the Indian Space Research Organisation programme—with a model of the Polar Satellite Launch Vehicle that launched the Mangalyaan craft, housing the Mars Colour Camera. Although popular (the story behind this mission has now been made into a film “Mission Mangal”), these objects and narratives have not made it back through to the gallery as it stands, despite other interventions in 2019 that changed the Exploring Space Gallery to include the Soyuz Capsule.

5.3 Summary

In this chapter, I have worked to show that through foci within the three galleries in London on making place in Outer Space (Messeri, 2016) and the various emphasis the locations where research takes place that builds the knowledge facilitating the place-making place are overlooked. I have demonstrated that Outer Space is made into places that are in reference to nationalist, gendered and sexualised imaginaries of the contemporary and recent past, and that by doing so, the galleries construct an apparently ‘universal knowledge’ that centres western Science without question.

In addressing absences in the gallery, I have developed five examples that have close ties to the British Imperial project. Through attention to the stories that are overlooked in (re)telling these narratives in the space, I draw attention to the mechanism of divorcing colonial exploitation and violence from space science in the galleries. I have also shown how the language of universality has been operationalised to show ‘objective’ and ‘complete’ science—which negates the possibility for alternative schemes of knowledge about space and removes a human mode of connection that could act as a bridge between the visitor and the gallery content.
By distancing the roots of space science from colonial exploitation and warfare, it is less clear in these galleries that the efforts to assert power over the extra-terrestrial has also always been a struggle to assert a dominant form of knowledge. I have taken a critical pedagogy approach informed by a queer feminist methodology, that has led this section of my thesis to critically address other parts of the systematic subjugation through white, cis, hetero, patriarchal colonial project in response to the first two of my research questions. The resulting construction of ‘science’ and ‘innovation’ as placeless, ahistorical, and without significant interaction with social norms of the time or of development allows research work in the area to be viewed perhaps less problematically that it might have been otherwise. Importantly, using the lens of affective inequality, I have demonstrated that these moves elide particular identities, locations and motivations that might otherwise have given points of access to a wider range of publics who visit these galleries.
Chapter 6: Queering the Science Museum

In this chapter I will consider the co-construction of knowledge by the visitor and the exhibition through the discussion of the ‘Queering the Science Museum’ tours, and explore the limitations of the form. I shall then reflect on the ways that a queer feminist conception of the science, as demonstrated in these tours, can in turn challenge and change the construction of the social world of science. I take as the central question for this chapter the third of my three research questions. This chapter stands as a new addition to the literature in asserting the mechanisms and possibilities of ‘alternative’ interventions in STEMM museum spaces.

As I have detailed in the two previous analysis chapters of my thesis, museums are not neutral spaces. The choice of object displayed, the story it (re)presents and is told with it, how and where it is positioned in the space, even which space within a museum it is placed within are all curatorial choices made over time that assert a political, social power in any given museum. As discussed, even the conception of what the museum is or should be itself has in recent years shifted – from somewhere that knowledge is displayed to a place where relationships and relational ideas can be accessed for knowledge construction by the individual (ICOM, 2019). Moreover, understanding that what is on display is a choice made by an individual or group, where rarely, if ever, are displays able to explore and present the multifaceted ideas that any artefact might contain, permits me to think about how museum educators of all stripes could access information that is not on display and share this with visitors.

Thus far in my thesis I have looked at three case study space science galleries in London to explore the first two research questions of this research. This chapter will instead focus on considering the third research question of my thesis:
Question 3: Through understanding these inclusions and exclusions as exercises of power, what are the roles of ‘alternative’ approaches to power, identity, and futurity in the museum gallery?

As a case example, which I shall relate to broader ideas about ‘alternative’ approaches, I have selected my ‘Queering the Science Museum’ tours that I ran during July 2018. These function as an example of an ‘alternative’ approach to power and identity within the museum. However, in addressing the exercises of power that exclude particular narratives, I will also be tying in thoughts and results from the first two research questions of the thesis. This will highlight how by understanding the inclusions into the spaces, interventions themselves can construct or challenge narratives in a museum space, as well as drawing attention to or filling absences in the space.

6.1 Existing ‘alternative’ narratives in STEMM museums

Longstanding debates about the roles of science, technology, engineering, mathematics and medicine (STEMM) museums as locations for exhibition of history of science or as locations of science in action prevail (as alluded to in the literature review), and such STEMM museums have remained reasonably isolated from concurrent debates that exist about representation, social justice and identity as has been written about in other parts of the museum sector. Whilst examples of interventions and challenges to the existing scripts of museums exist (e.g. Curran, 2019b; Dodd et al., 2010), they rarely if ever take place in the STEMM museum. Indeed, the 2019 publication of Museum Activism (Janes & Sandell, 2019) included only one chapter on a STEMM topic, climate change, and the material was not presented in the context of a STEMM museum.

Additionally, I have also demonstrated earlier in this thesis that whilst other scholars are beginning to integrate queer theory and science and technology studies (e.g. Cipolla et al., 2017), little has been done to foreground these issues in public arenas of science
communication to date. Researchers (including Dawson (2019), Francis et al. (2017a, 2017b), Machin (2008) and Rodéhn (2019)) have demonstrated that STEMMM spaces (re)produce gendered performances; whilst less research exists, it is clear from other theorists and practitioners that these museum spaces are also racialised (Das & Lowe, 2018), sexualised (Cassidy et al., 2016), and ableist (Dodd et al., 2010).

To give a flavour of some of the interventions that are currently taking place in the field of STEMM museums, I highlight three interventions that have taken place in London. The first of these is ‘Bricks and Mortals’: a tour that runs both in person and as an audio guide around the buildings of University College London. Initiated by Subhadora Das to highlight eugenics and “the racist and colonialist roots … [that have] seeded research today” (Samarasinghe, 2017), the tour features both a podcast or guide and bright yellow plaques around UCL buildings that draw attention to the eugenics research undertaken in the past in University College London buildings where contemporary research continues to be done today (UCL, 2017).

Secondly, Dr Ellie Miles, Documentary Curator at the London Transport Museum, initiated and led ‘Where are all the Women?’, a project that co-created new museum display plaques about “female family members, ancestors or employees who may have worked in the transport industry” (Miles, 2019). By soliciting contributions from members of the public with first- or second-hand knowledge of working in the transport networks, the project has developed new narratives that sit within the galleries as counterpoints to the hegemonic narratives about who worked on, travelled by and invested in public transport.

The third case is ‘Slavery and the Natural World’ (Natural History Museum, 2017) – a book, tour, and zine at the Natural History Museum, London which detailed the interlocking and reproducing mechanisms of natural history and subjugation, making the museum “a site of rediscovery as much as passive observation” (Okoye, 2017). In particular, this tour sought to foreground how:
The association with a particular past excludes those whose heritage is wrought with the trauma inflicted by the ‘modes of operation’ that enabled these institutions to exist. (Okoye, 2017)

In all three instances asking what I consider queer, feminist questions (as detailed in my Introduction) is central to the intervention. By considering who is working in these STEMM fields, what it means to be doing work or producing knowledge in STEMM – and by extension who gets credited, acknowledged or ‘used’ in doing so, and in which ways – all three projects challenge and reshape the way the spaces around them can be understood and engaged with by visitors.

These three projects call attention to distributions of power in the galleries that they occupy. As I have detailed in the two previous chapters, being attentive to the relationships between power and knowledge in the gallery is vital. Understanding the ways that knowledge feeds into narratives that are created within a museum gallery allows better understanding of the exercising of power and reinscription of cultural hegemony and the ideas of ‘truth’ in the gallery (Bennett, 2017).

Miles’ work calls attention to how “genders and sexuality are performed, as a product of power relations” (Fry, 2012). Having differently coloured plaques through the galleries highlights, by showing and creating alternative narratives, that there are existing discourses about what the gender and sexuality should mean in the engineering and technical space that is a transport museum. Thus, in installing permanent additions to the gallery in coloured plaques, I suggest that these exhibitions are moving towards a Foucauldian idea of a museum as a space where alternative narratives about society can emerge, challenging the way that different subjects are formed in the museum space.

I have included these examples to demonstrate that the interventions I ran in the Science Museum were neither the first of their type nor the only way that intervention could take
place in a STEMM-focused heritage site. While earlier in my thesis I have demonstrated other examples of interventions in museums that draw attention to inclusions and exclusions in knowledge construction and how this can be seen as an exercise of power, the three examples I have given here are specific to the ways that power and knowledge are exercised as tools in STEMM spaces.

It is of particular importance to think about racial, gendered, classed, ableist and sexualised scripts of knowledge-power and identity in STEMM museums. Appeals to objectivity in STEMM museums are made in the same ways that appeals to objectivity are made in science. I return to Prescod-Weinstein’s argument, critical of the ways objectivity has been and continues to be constructed in physical sciences:

White empiricism is the phenomenon through which only white people (particularly white men) are read as having a fundamental capacity for objectivity and Black people (particularly Black women) are produced as an ontological other. (Prescod-Weinstein, 2020, p.421)

As such, I wish to extend the Prescod-Weinstein’s argument to see the same appeals to scientific objectivity in STEMM museums as being tied to the same explicitly racialised, gendered narratives of knowledge and thus power within the galleries. Not only does this exercise foreclose ideas about the ways that STEMM ‘could’ be, it also narrows experiences of how STEMM is at the time. By developing these interventions in all three cases, subjects were created in the galleries that challenged the idea of objectivity, certainty or abstract ‘truth’; instead they demonstrated plurality, subjectivity and the contingent nature of the knowledge that can be and is represented in these museum spaces, and therefore cultural discourse more generally.

In this chapter, therefore, I make three claims as additions to my thesis. The first claim explored is that the ‘Queering the Science Museum’ tours provide an example of a conceptual pathway for drawing on queer approaches found in socio-historical and arts
museums in STEMM spaces. I will demonstrate how the tours allowed me to discuss and make anew queer feminist approaches within the STEMM museum. This will be built through introducing the Queering the Science Museum tours, reflecting my work on the tours into practices of tour-guided interventions and ideas around queer feminist approaches to heritage sites, and then by demonstrating some of the essential features that unite my work with arts and socio-historical interventions. The second claim I make is that the ‘Queering the Science Museum’ tours move beyond the existing models of engagement in socio-historic and arts museums. The third claim is that it is inadequate to believe that the tour-as-intervention is enough change within the museum to realise a queer feminist approach. To do make this final claim, I shall highlight theoretical, methodological, and practical problems about the tour format, and demonstrate that these render the tour alone as insufficient intervention. I shall conclude with a summary of these arguments, leading into a final section that suggests ways that the tour may be viewed as one of many ‘alternative’ approaches on which to build further inclusive practice.

As described in Chapter 3, I have used multiple methods in the creation of this chapter. First, the chapter presents the results of the research, development and execution of the tours. Approaches I use are drawn from action research have been used to inform the development of the tours, as well as having helped me to understand the tour as part of the method of knowledge (co-)creation in the space with participants. Throughout this chapter I will specifically draw attention to the particular parts of the tours that were strongly informed by the methodology and methods previously described. I then depart from the tour as a way of reflecting on the work of myself as a research in conjunction with the participants on the tour, to understand their comprehension of and response to the material. I shall draw on autoethnographic data from delivering the tours, as well as incorporating the voices of participants through their completion of a quantitative and qualitative survey. Critiques of these modes of data collection as methods have been discussed in relation to my methodology in Chapter 3. By being methodologically informed by the queer feminist approach I detailed at the beginning of my thesis, this
chapter demonstrates that different methods and approaches can be used to develop plural findings and perspectives in the results and discussions presented in my thesis.

6.2 Queering the Science Museum, July 2019

Around the edges of the work I did as Explainer at the Science Museum there were little gaps and spaces – moments of walking between locations in the museum, preparing props for shows in a small, flour-covered backstage room, training learning shows, leaving the museum together at the end of the day, where friendships, collegial relationships and collaborations are born. Meandering through galleries, I would stop with friends and look for objects, texts, pictures. A mode of the Pill (object number: 1994-1329), Alan Turing’s ACE computer (object 1956-152 Pt1), the models of ‘evolution’ of boats running concurrent with increasing whiteness (objects 1932-69; 1932-68; 1932-67; 1932-66).

Looking for mentions of women scientists to which I could direct parents when they inevitably asked, sharing information about adjacent objects to the ones we talked about in demonstrations. We looked for interest, for developing our knowledge of the building that people expected us to direct them round, and I looked for queer feminist stories. This position of being an insider to the building, spending 18 hours there a week, but an outsider to the construction of the galleries, was the basis of feeling for and finding the ‘cracks and fissures’ (Sanders, 2008, p.24) in the normative narratives in the museum spaces.

Built from these informal wonderings – taking deviations from the direct route from activity to activity – Queering the Science Museum grew into guided tours of the Science Museum, London. The intervention was developed, led and reviewed by myself with some contributions by Damien Arness-Dalton; it was built on a foundation of months of being in the space, being shown some items by friends, reading about others in my research and discussing many more with other colleagues from different parts of the Museum. We were supported to pay for the research by the British Society for the History
of Science Outreach and Education Grant in 2018, which allowed the tours to run for around an hour every Saturday and Sunday in July 2018 free of charge to attendees. Arness-Dalton and I co-ran two tours; he ran one alone and the remaining six of the tours I led. We welcomed approximately 120 people over the course of the tours which were advertised on social media and by word of mouth.

At the time of running the tours, both Arness-Dalton and I worked (and had been working) at the Science Museum as part of the Museum’s Learning Team, running events and demonstrations and engaging in one-to-one interactions with visitors to the museum; we therefore had a good understanding of the range of people who came to the Museum. In 2017, the year previous to when the tours ran, the Science Museum reported over three million visitors; standing at around 6% of the total visits to Galleries, Libraries, Museums and Archives across the UK that were funded by the Department for Culture, Media and Sport (DCMS, 2018). Moreover, around 390,000 educational visits for young people were made to the Science Museum that year (DCMS, 2018), more than to any other single Museum, Library, Gallery or Archive in the UK. Thus, motivating our guiding at the Science Museum above the other museums that have been part of my thesis were both the popularity of the museum as a space for informal science education, and our familiarity with the collections at the time of developing the tours.

Around the summer of 2018 there was significant interest at other institutions across the heritage sector in the UK to make queer histories more visible, coinciding with both the 30th anniversary of Section 28 – a 1988 British law which prohibited local authorities from “intentionally promot[ing] homosexuality or publish[ing] material with the intention of promoting homosexuality” and also did not allow them to “promote the teaching in any maintained school of the acceptability of homosexuality as a pretended family relationship” (Local Government Act 1988, 1988, Section 28) – and the 50th anniversary in of the partial decriminalisation of homosexuality in England in 1967. Exhibitions included, but were not limited to, Queer Art at the Tate (Tate, 2016), Gay UK: Love, Law and Liberty at the British Library (British Library, n.d.), Desire Love and Identity:
Exploring LGBT Histories at the British Museum (British Museum, n.d.), and the Prejudice and Pride programme at the National Trust properties across the UK (National Trust, n.d.). Alongside these installations, many institutions started guided or self-led tours around permanent collections including “Queer Walk through British Art” (Tate, n.d.), “Out in Oxford” (www.glam.ox.ac.uk, n.d.), “Beyond Binaries” (museums.cam.ac.uk, n.d.), “LGBTQ Tours” (Victoria and Albert Museum 2018) and LGBTQ Trail (Brighton Museum, n.d.). Whilst there is a growing collection of such interventions, and a body of literature situating these within in queer theory and museum studies, I could not find evidence for other, similar, interventions in science or natural history museums\(^3\). It was this gap that the Queering the Science Museum tours sought to address.

In constructing the tours, Arness-Dalton and I initially framed the selection of stops on the route and its development around two questions:

1. Can we begin to unpack our [queer] identities and lived experiences through the science museum collections?
2. Can we use them to reach new perspectives and understandings of ourselves by looking at these collections through a fresh queer lens?

Both of these questions allowed us to spend time thinking not only about queer or LGBTQ+ identity, but also about the ways that we might bring in queer Science and Technology Studies material to the tours.

### 6.2.1 Example object on the tours

\(^3\) At the time of delivery of Queering the Science Museum this was the case. Currently (2020) the ‘Bridging Binaries’ tours have expanded to include tours at the Whipple Museum for the History of Science, and the Sedgewick Earth Sciences Museum in Cambridge, that I wrote during 2019 for tour guides to deliver.
To give a flavour for the content of the tours, I will explore one of the stops we made on the tours: The Spitfire plane in the third floor Flight Gallery at Science Museum (2020). The Science Museum has used this object to illustrate variously RJ Mitchell the engineer behind the Spitfire (Science Museum, 2009), the uses of aircraft in the military (Science Museum, n.d.), and the desire for speed in a race to go ever faster (Science Museum, n.d.). However, by queering the question of what the use of this object could be and by whom (Ahmed, 2018), we instead discussed pilot and engineer Roberta Cowell. Cowell had studied Engineering at University College London from 1936-39, where she met her wife, Diana Carpenter, a fellow Engineering student, with whom she had two children. Cowell was a keen racing car driver, competing in the 1939 Grand Prix; but by 1942 she was flying Spitfire planes for the Royal Air Force (UCL, n.d.).

Roberta Cowell was identified at birth as male, but had gender confirmation surgery in 1951, and lived the remainder of her life as a woman. It was through her friendship with Michael Dillon, the first man to receive phalloplasty surgery, that she was introduced to the Harley Street doctors who performed then-pioneering gender confirmation vaginoplasty surgery on Cowell. Her friendship with Dillon speaks to intersecting privileges of ethnicity, class and nationality – such surgeries were neither common nor happening around the world at the time. Many resources about Robert Cowell’s life, written from 1952 until after her death in 2012, are problematic sources for learning about Cowell’s life. Frequently using a mixture of pronouns and gender identities (for example referring either to Cowell using ‘he/him’ before 1952 and ‘she/her’ after), or drawing on and quoting sources that do, makes research difficult. More recently, arguably from 2017 onwards, there is a growing consensus in the sources I found in my research to use only she/her pronouns, moving away from dead-naming (i.e. using the name Cowell had prior to transition) Cowell, and towards asserting her identity as a pioneering woman.

However, in telling this story on the Queering the Science Museum tours, Coward’s and Dillon’s stories were not only evocative of their lives and the experiences of those who were recipients of early gender confirmation surgery but also allowed us as tour guiders
and tour attendees to think critically about which stories we are able to tell in the museum space at all. We are able to know so much about Cowell, and to discuss her life in detail, because of her autobiography: *Roberta Cowell’s Story by herself* (Cowell, 1954). There are other individuals whose lives are much less well known: we pointed on the tours to people such as the medics Alan Hart (O’Hartigan, 2002) and James Barry. Both of these individuals have at various points been discussed as trans, intersex, gender non-conforming or cross-dressing (see, for example, the discussion in O’Hartigan, 2002) – and ongoing historical debate seeks to situate them in such a way that their ‘identity’ is firm and fixed. Taking James Barry for instance, widely believed to have been born in around 1789 and identified female at birth in Ireland, he moved to Edinburgh to study medicine in 1809 under the name James Barry (presumed to have been inherited from uncle and Royal Academician, James Barry). Unlike many women contemporary to Barry, who studied and practised medicine at the time under male names and pronouns, but later in life reverted to their feminine gendered identities, names and pronouns in retirement, Barry retained both name and pronouns (he/him) until death – signing his will with these terms.

In *This Vexed Question* an exhibition about Women in Medicine at the Royal College of Physicians (2018), another STEMM heritage site, this narrative has been described as:

James Barry had an extremely successful international career as a military surgeon in the British Army, rising to the rank of Inspector General.

When Barry died in 1865, their body was revealed to have the biological characteristics of a woman. Barry was born Margaret Anne Bulkley, but from around 1808 onwards lived as a man. We do not know whether Barry identified as a man, or obscured their gender as assigned at birth in order to become a surgeon. (Royal College of Physicians, 2018)

Compared to our presentation of Barry on the tours, there are notable differences in the choices of using pronouns that the individual had expressed at the time of their death (in
this case, he/him), the idea of being able to understand what ‘biological characteristics of a woman’ are (by which, we might assume the label means a vulva, breasts, or possibly the absence of a penis – which in itself collapses the ideas of gender/sex into a single dimension), and the obfuscation in the label of the fact that Barry had explicitly asked for his body not to be examined upon his death. Most of all, the central contrast is the inclusion of Barry in an exhibition about women at all. This is characteristic of erasing trans and/or gender non-conformity as being a valuable or valid identity in its own right, as Procter noted:

YOU DON’T GET TO BE SMUG ABOUT INCLUSIVITY WHEN IT’S ACTUALLY TRANSPHOBIA IN DISGUISE (capitals in the original, Procter, 2018)

While on our tour, this stop on the tours took the Spitfire as a point of departure, the conclusion was far more about how we can look into the past, whose identities are valued and preserved as the individuals may have thought of themselves while they were alive, and what the role of having the power to write an account of oneself rather than being recorded by others during your life or in death is. I tried to pull to the fore the idea that queer historiography does not require us to have a firm answer, but that uncertainty around historic identities is something we can become comfortable with.

Elsewhere on the tours we also covered representation of contemporary trans identities as binary positions (‘Boy or Girl’) and the use of labelling around anonymity or elision of identities. We talked about the idea of genetic testing for queer identities against culturally identifying oneself as queer, the construction of monogamy/polyamory in relation to oxytocin research on vole rats, Billy Doll toys, Alan Turing and his work, and the role of nursing and medicine as respectable professions for upper class women in the late 1800s-early 1900s who were romantically interested in other women. We attempted to make it wide ranging in terms of the identities we discussed and the perspectives and critical angles we shared with those on the tours.
6.2.2 Drawing on socio-historical and arts tour work

As Ferentinos queries:

What is it, exactly, that makes an object queer? Does the fact that a queer person owned an object qualify it as a queer artefact, or must it be related explicitly to its owner’s sexual identity? (Ferentinos, 2015, p.112)

Winchester (2013) argues, when writing about the Victoria and Albert Museum LGBTQ tours, that there are three ways to introduce objects into a queer tour: either the subject, or the maker were queer, or the object is important to the LGBTQ+ community. It is clear how in a socio-historical or arts museum these categories can be used to consider an artefact for inclusion on a tour – and many museums have engaged with this (see my coverage in earlier chapters).

Many of the objects on the Queering the Science Museum tours fit into these categories too. For example, the case of Roberta Cowell I have recounted above could be read as included because the user of the Spitfire plane as the museum object was LGBTQ+. As STEMM artefacts do not often depict ‘subjects’ in the same sense as in a work of art, I have chosen to take ‘subject’ to be the position of the user – i.e. someone who did not necessarily make the artefact but was engaged with it in some way. Perhaps closer to this interpretation of Winchester’s thoughts are the way that Prejudice and Pride, a project with the National Trust, engages with LGBTQ+ heritage at National Trust sites, grapples with including the heritage of the ‘users’ or owners of the houses, for example, Vita Sackville-West and Harold Nicolson at Sissinghurst Castle (Dodd et al., 2018). Exploring the queer lives of those who lived at the National Trust properties that the projects happened at allows me a way in to think about the people in those spaces as subjects, rather than the workers (craftspeople, builders, land farmers) of the houses whom we might consider in Winchester’s rubric to be equivalent to ‘makers’.
Our inclusion of a facsimile of Alan Turing’s paper and the ACE computer (Object Number: 1956-152 Pt1) was on the grounds that he, the maker and writer of the paper, was LGBTQ+. Others like Florence Nightingale, as developer of statistical methods and diagrammatic representation, were included for the same reason and highlight the prevalence of LGBTQ+ identities of STEMM individuals.

Finally, we included objects such packing materials, testosterone patches and a binder, and the Billy Doll (Object Number: 2000-584/2 Pt1) because of their relevance and importance to queer communities. Drawing on interventions such as the Museum of Transology which centre objects important to individuals or communities, for example a My Little Pony doll, that are not necessarily made by them or of them, but instead carry valuable meanings as signifiers of transition the community (see, for example, discussions in Stone, 2020). In the case of the Billy Doll, we discussed its importance to the Gay community of 1990s America and London, who held Billy ‘coming out’ parties, and bought the doll in droves when it was released in 1997. This ‘anatomically correct’ doll with a large penis represents an object marketed to queer communities, and allowed us to access stories about the changing acceptance (or lack thereof in the museum gallery) of sexual identities over time.

6.3 Discussion of additional modes in Queering the Science Museum

However, other objects we included on the tours don’t fit neatly into these categories suggested by Winchester. Our discussion of the vole rats and biological research around the construction of monogamy/polyamory, or the inclusion of ideas around the ‘gay gene’ in the discussion of genetic research centred on DNA (Object Number: 1977-310) could not properly be constructed as being within any of these existing categories that Winchester proposes and have been discussed above. I believe this shift has two different geneeses. First, I think this shift can be framed as a shift from an ‘LGBTQ’ tour towards a
‘queer’ tour. Through the Queering the Science Museum tours, I will develop a claim of a fourth ‘Queer Critique’ category that stands by itself as a mode of engaging with queer heritage through a tour. Secondly, this change is towards a criticality of the museum that desires action for change. As such, this fourth category could be constructed as moving the tours away from being simply a recounting of stories in a hegemonic manner, into a queer critique approach to the tours.

Apart from their identification as queer, how different is the recounting of a story about Florence Nightingale to one about Dorothy Hodgkin if the narrator or tour guide relies only on normative modes of drawing on, presenting or praising the galleries the objects sit in? Instead, this fourth category provides scope for critique, queering the authority of the institution – reclaiming it for an alternative, queer, narrative about science. Queer can be understood as an approach that challenges the location of the subject (Green, 2007), normative practices (McCann, 2016), fixed identities (Jagose, 2009) and narrative unity (Winchester, 2013).

6.3.1 Narrative unity

Echoed in this idea of queer critique as a strand to these tours is Mills’ theorising of the queer museum – presenting “queer [as entailing] a refusal of meaning, registering a kind of disruptive negativity and incoherence at the heart of identity, language, and law” (Mills, 2008, p.46). Disrupting the fabric of narrative by attending to the absences in the story, this queer critique challenges the:

coherence, objectivity, clarity, and narrative unity, ordering the objects of human or natural history in such a way that they can be consumed, often selectively, by an uninitiated viewing public. (Mills, 2008, p.46)

I maintain that the tours were also a challenge to the narrative unity of the museum galleries that had been constructed in each gallery space. By selecting items that were
spaced around the museum across galleries, floors, themes and zones, the tours were able to disrupt the unity of any single narrative in a gallery. I will return to these movements around the museum later in this chapter, to consider how this movement of queer bodies within the museum spaces while acting as a disruption and challenge to the unity of the museum also was attempted to be regulated by members of the Museum itself.

Further, even within particular galleries we often juxtaposed or pointed out the ‘incoherence’ (Mills, 2008, p.46) within the galleries – highlighting for example, the positioning of vole rats at the bottom of a case that otherwise presented information about gender/sex in humans or only selecting the Billy Doll and the model of DNA within a gallery on Making the Modern World. These selections and choices – particularly as they deviated from the scripted meanings of the artefacts within the galleries, instead queering their use (Ahmed, 2019) as pedagogical objects – refused the meaning of the objects as dictated by the museum. Moreover, rather than simply telling participants a different narrative to the one in the gallery, we frequently drew attention to the refusal of meaning that had been constructed in the gallery. With both the Billy Doll and the Boy/Girl Cabinet, we both read the exhibit labels aloud and discussed the exhibit construction in conjunction with participants – soliciting their thoughts about the wording and display. I argue that this not only rejects narrative unity within the space, but also highlights exclusionary modes of constructing knowledge narratives in the museum about valid identities and experiences, and challenged the hegemonic constructions of power in the space, which I will explore further in the next section.

Conversely, however, I would argue that in order for the tours to make sense to me while delivering it, and to provide a kind of storyline structure to the event for participants, the tours did not reject connected meaning making across these spaces entirely. Not only was the final image of the Pioneer Plaque used as a summative reflection of the other points developed over the course of the tours; rather, the tours were developed in such a way that it internally referenced both forward and backwards to other objects that had been discussed, evoking queer time. Thus, unlike tours that queer a space by entirely (e.g.
Fraser, 2005; Hoyle, documented in Tate, 2012) rejecting narrative and continuity, Queering the Science Museum instead created its own internal narrative at the rejection of the narratives within the museum galleries themselves. Perhaps here, ‘queer’ as a challenge to narrative unity was only against the existing narrative of the museum, leaving unified narratives themselves not sufficiently challenged in the tours series I developed.

6.3.2 Normative practices

As asserted at the start of this section, the Queering the Science Museum tours did more than just highlight queer individuals. Importantly, we sought to bring to light some assumptions about normative practices of society that the queer approach helped showcase. I will deal here with two absences within the normative narrative of the museum that highlight and demonstrate power exercised within the museum gallery.

6.3.2.1 The One / The Other

Museums tend to centre the story of the ‘one’, that of the ‘centre’ or the ‘insider’; by instead focusing on the ‘other’, ‘outsider’ or ‘periphery’ we were able to construct a tour that demonstrated how:

> a focus on outsiders has the potential to reveal a great deal about the society as a whole. Various eras and cultures have defined the boundaries of what is considered "normal" differently, and by exploring those differences – and the experiences of those who were considered "abnormal" – we can catch a glimpse of the assumptions and priorities of the larger group. (Ferentinos, 2015, p.7)

As such, while the Science Museum galleries have to date tended to focus on the insiders of science – typically white, western, cis, straight men – our Queering the Science Museum tours were keen to feature the stories of ‘outsiders’ such as nurses, pilots or technical engineers, and especially queers of colour. The use of queer to focus on absent
stories of ‘STEMM’ professionals that did not sit within the normative existed as a challenge to the museum’s authority and power in inscribing who and what is deemed to be ‘STEMM’ by the museum as an institution.

6.3.2.2 The museum collection

Moreover, beyond challenging just the ideas about what STEMM might mean as a professional identity, we were also able to use queer as a way of highlighting the choices made in both collecting and displaying. Mills redresses the museum:

> It is also possible to imagine exhibitions that not only draw attention to the normalizing dimensions of collecting and classification as cultural activities ... but that also reveal collecting itself as a potential site of queer affect and desire ... [such] projects would turn, self-reflexively, on the notion that the objective, narratorial voice of museum authority is not the only voice to be heard. (Mills, 2008, p.48)

For instance, in including the Billy Doll (Object Number: 2000-584/2 Pt1) in the Museum’s collection, we can see an object that is not explicitly to do with science, technology, engineering, mathematics or medicine but still is related to the impacts of medicalisation and government policy on LGBTQ+ communities in the USA in the late twentieth century. Moreover, in Making the Modern World the Doll is labelled in the cabinet as being “relevant to communities” (Making the Modern World, 2018) without specifically noting which community, and sits alongside Barbie without comment. By drawing attention to the doll, we highlighted in the tours both the affect, desire and intent that are implicit in its presence in this gallery space, as well as the silence around the Doll’s meaning and story to those not ‘in the know’. By celebrating and telling this story, not only were we revealing this queer desire to develop the story, but also providing a different narratorial authority in the gallery – giving specific details about the queer community to which this Doll was important. Indeed, the ability to challenge the narrative
through these queer tours was picked up by participants on a tour, one of whom commented:

It gave an alternative history in a space where the stories told about objects are often accepted without question. It really opened my eyes to the ways in which history is shaped by those who have the privilege to tell their stories from their perspectives. I thought it was incredibly important. (Respondent to Queering the Science Museum Survey, 2018)

Another participant noted that it was not just that a singular ‘alternative’ narrative that was presented but rather “[m]ultiple perspectives were explored and discussion was encouraged” (Respondent to Queering the Science Museum Survey, 2018), indicating we opened a queer plurality to the normative narratives around artefacts permitted and the voices allowed to be telling them. In addition to the narratives embedded in the gallery, through Queering the Science Museum we added the narratives we included on the tours, the narratives that participants shared with us and with each other.

6.3.2.3 The tour guide as authority figure

The queering of the hegemonic motif of the way that participants ‘experienced’ the tours was also important to me. To explicitly challenge and destabilise the idea of authority of a narrative, I opened the discussion at the start of each tour to value contributions of anyone else who came on the tour – both by encouraging them to contribute and by giving everyone on the tour the chance to introduce themselves and from there co-create knowledge and experiences with each other as we moved around the museum together. Through queering the tour format as well as the tour content, we encouraged a different approach to finding:

queerness historically or culturally might be a means of responding to the gaps and omissions that condition museum practice, and of ensuring that the meaning-
making structures of the museum are themselves subjected to evaluation and critique. Such an analysis would participate in the general shift from object-centered to experience-centered understandings of museums in museum practice. (Mills, 2008, p.50)

Not only did we encourage queer voices, queer narratives and queer expressions around the museum, but through stops such as the summative critique with the Pioneer Plaque we moved to a call-to-action as part of the experience too. By drawing attention to these absences and suggesting modes of actions, the tours opened new thoughts for participants:

I liked the combination of queer histories and critiques of the Science Museum’s presentation (or lack thereof) of queer content. (Respondent to Queering the Science Museum Survey, 2018)

This challenge of the experience over the object (which is often itself absent in queer heritage) that Mills draws to light is perhaps seen echoed in the 2019 ICOM discussion – a movement towards understanding the visitor in the space rather than simply the space itself. The participation and development of ‘queer’ within the museum can perhaps been seen in the opening action of the Victoria and Albert Museum LGBTQ tours, where the leader of guides for the day asks everyone attending the tour to shout ‘Queer’ in the gallery space – claiming that moment as an experience in the gallery space of objects, rather than simply the objects as priority.

6.3.2.4 Subverting hegemonic histories of science

Queer activism also allowed us to subvert the power of normative history of science. To me, this is seen clearly in that 57% of respondents to our questions expressed that they would not have come to the Museum that day had the tours not been running; moreover, 41% of respondents who did not work at the museum, had not been to the museum within
the past year. The tours engaged with queer activism as a motivation to learn about history of science:

I liked the fact that it wasn't just about queer scientists (although that was very interesting) but also flawed scientific studies/the lack of scientific studies on sex/gender issues. (Respondent to Queering the Science Museum Survey, 2018)

I was expecting it just to focus on figures from the history of science who'd been over looked / discriminated against (like Alan Turing) (not that focusing on these is a bad thing) but it went into much more detail. (Respondent to Queering the Science Museum Survey, 2018)

It also took something – science – which we don't often look at through a queer lens. (Respondent to Queering the Science Museum Survey, 2018)

To me it also cannot be overstated that this was not people turning up and expecting to hear the stories that we told – much like one might anticipate stories about the statue of David by Michelangelo at the Victoria and Albert Museum to be known by the tour attendees. Over 70% of people who responded to our queries only knew either one or none of the seven stops we made on the tours, and the one story people had heard of in this category was of Alan Turing. Whilst many people indicated (both in person during the tours and through the feedback we received) that they were interested and versed in queer heritage, there was a distinct lack of knowledge about how this could be used in approaches to STEMM. I argue that this is directly linked to the perceived co-location of queer or LGBTQ+ identity and socio-historic or artistic spaces. I will return to the importance of my work to challenge these norms in the concluding chapter.

6.3.3 Location of subject
Foucault argues that knowledge and power transform human beings into subjects (Foucault, 1982) in different ways at different times and different places. These tours facilitated individuals to understand themselves as a subject – making a ‘subject of sexuality’ through which individuals know themselves. In the space of the museum, the Queering the Science Museum drew attention to the narratives that allowed individuals on the tours to conceive of themselves as ‘queer’ and ‘scientific’ – two parts of an identity that might otherwise be held separately.

However, as discussed in relation to Sexual Nature exhibition (2011), exhibits in public settings frequently normalise queerness within them:

[Given] a more radical queer perspective ... the exhibition was still very heteronormative, [reflected in] yet another set of messages – this time about appropriate forms of homosexuality and other sexual behaviours. (Cassidy et al., 2016, p.232)

Although we featured and queerly critiqued science around polyamory and monogamy in vole rats, and discussed subversive relationships created and maintained by the Gay and Lesbian phonelines, most of the stories were reasonably homonormative. This is likely to have been a result of a number of factors – the selection of objects, our first attempt at challenging the narrative in this way, the uncertainty about perceived expectations when returning a project write up to the British Society for the History of Science after the work, and, personally, insecurity in being the leader of more explicitly queer tours.

Such reflections highlight a difficult power structure at play in the development and production of these tours. Arness-Dalton and I were not funded or supported internally by the Science Museum despite working there but ran the project outside the official paths of the museum. I still required the income and job security of the role I held there, and whilst the collections are public and do not require booking to lead tour groups, the
museum might look unkindly on an internal/external critique. This is not to say that the museum was against the tours – indeed we invited the director who politely declined, while heads of Front of House, Archives and the Learning Team were supportive of the work and encouraged their staff to attend.

This being said, the tour groups did draw attention of the security guards and others in the museum. LGBT bodies touring around the museum could be read as “successfully defined as deviant [and] subject to intense surveillance” (Tomsen, 1996 p.4), such that on entering each gallery our groups were followed round by security, who radioed ahead to the next gallery on overhearing where we were going. Thus, much as the tours allowed us to pluralise the identities of those who are considered ‘STEMM’ professionals, it still described an ‘in’ group and an ‘out’ group, those perceived and understood as welcome subjects within the museum and those deviant and surveyed. This understanding of making insiders and outsiders allowed me to pluralise what is meant by ‘the museum’ to myself. As Motto (2016) notes, different people in different parts of the museum have different understandings of what the museum should be and to whom. However, I would argue even at different times, the same person (such as myself) may have different relational positions to the museum and its projects.

### 6.4 Limitations of Queering the Science Museum

It is also key to reflect on the limitations of the tour. In the previous section, I described and theorised some of the limitations of the ‘queer’ approaches I took to developing the tours. I will here move on to describe some of the more general challenges of tours as interventions into gallery spaces. I shall draw together these limitations in relation to theoretical, methodological and practical aspects at the end of the section. As such, the

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4 In another, previous (but much smaller) critique of the Museum that I made publicly, I was internally reprimanded by my manager, suggesting that action by my employer was both possible and probable in this event.
section will conclude with a claim that both types of limitations can be understood as motivating an urgency in changing practice in permanent displays, rather than motivating further temporal interventions.

6.4.1 Practical limitations of tour guiding

Studies elsewhere in the literature suggest that tour guiding or live interpretation provides museums with a mechanism for high quality engagement. For example, Gammon and Mazda (2003) highlight the dialogical nature, comprehension, dual listening and looking, spontaneous adaptation of subject matter to audience at hand, depth of content, ability to highlight salient features of the curation and highlighting non-obvious features as particular benefits of the tour format.

Tours, by their nature, are only accessible at a given time, and to a limited number of individuals. Who is able to come to the museum at 11am on a Thursday? Or to a late Friday opening? Who perceives a guided tour as something that they will be welcome on? The same limitations of distance, cost of entrance, and perception of a museum being ‘for me’ exist for tours (Dawson, 2019). Additionally, we must attend critically to accessibility of tours: are the tours that contain content ‘extra’ to the gallery signed and visually interpreted, and do they permit movement of persons of disability around the whole tour as a result of the museum infrastructure? While many museums do tours that are signed or visually interpreted (e.g. VIscovery at Science Museum Group sites), these will often be to allow access to the content as it stands in the gallery rather than ‘extra’ content that could build empowerment within the spaces. The only intervention where the LGBT tour content was also available in a signed format was the Queer British Art tour at the Tate (n.d.). One colleague also discussed with me the challenge of visitors deeming their tour of the Fitzwilliam Museum in Cambridge ‘age inappropriate’ for children or young adults, and self-electing not to come on the tour. Tours on sexuality, in particular, are often thought (presumed) to be inappropriate for younger visitors (see, for example,
Dodd et al., 2018), and this perception can limit those who self-select to come on LGBTQ+/queer tours.

However, as Best (2012) highlights, there has been very little research in the literature or in practice about the methods and modes of improvement of tour, “leaving us with little knowledge of the opportunities and challenges that their work affords museums” (p.35). Best highlights that, as a result, there is little knowledge about the practice of guiding in terms of interactive sequences, audience engagement and contribution, and training for guides. I would add to this that it also means there is scant literature about the barriers that tour guiding may erect for particular people because of how it is formulated and undertaken.

I shall now explore a series of barriers to visitor participation in tour guiding, and reflect on how they were apparent in the Queering the Science Museum and other tours that I have guided5. I believe that these barriers are important to acknowledge at length if I am to make a sustained and considered case for including the content of the types of tours described in the first section of the chapter not only in tours, but within permanent galleries – building on the previous two chapters and their discussion of queer possibility within the permanent gallery.

Whilst many of these barriers may be known implicitly to professionals who engage in tour guiding, I am yet to find them brought together. Just as Dawson has explicitly drawn attention in museum circles to considering the absent visitor and their needs in developing the museum (Dawson, 2019), despite museum professionals’ knowledge that Falk’s (2016) model only considers those who already go, I believe that drawing explicit attention to the problems of relegating progressive content to temporary tours currently

5 I also guided tours at the Victoria and Albert Museum, The Polar Museum, Cambridge, and have written guided tours for the Whipple Museum of the History of Science, and the Sedgwick Museum of Earth Sciences
just as tacitly acknowledged by tour guiders and institutions can provide motivation for progress. And, just as providing free ‘Golden Tickets’ to individuals does not wash as systematic change to challenging these access barriers (Dawson, 2019), putting on (often volunteer-led) tours that highlight content critical of racist, sexist, homophobic, imperialist historical or contemporary practices, or celebratory of identities that are not seen in science museums, is not systematically making the museum space more inclusive or more diverse. The account of these barriers is not exhaustive, and I draw on my experiences, conversations with other professionals and the literature to articulate them. I shall articulate the barriers of temporality and serendipity, access, individual decisions of the guide, artefacts on display, thematic tours and expertise and the sanctioned narrative.

Unlike permanent exhibitions (and, to a lesser extent, temporary exhibitions), guided tours are temporal in the extreme. For Queering the Science Museum, we ran the tours on Saturdays and Sundays at 4pm in July due to limitations of our budget in the grant from the British Society for the History of Science. As many museums have tours led by volunteers, they may not be advertised in print or online in advance in case the uncontracted volunteer is unable to make the slot. Regardless of whether they are or not, the tours are begun at particular times of the day (commonly hours between 11am and 4pm – for example, both the Bridging Binaries at the University of Cambridge Museums and the LGBTQ Tours at the Victoria and Albert Museum I guide on start between these hours), and missing the tour, or even the start of the tour, means that the content is then unknowable to the visitor who hasn’t participated on the tour.

While leading other tours around museums, I have often had visitors who overhear parts of the tour, and, serendipitously being in the vicinity, are able to join the tour if it meets their interests. Such visitors have mentioned to me afterwards that they did not know that the museum ran guided tours, nor where they met, but that they enthusiastically felt that experience had improved their time at the museum significantly. By isolating the content, especially that on racialisation, class, sexuality, gender or (dis)ability, to a guided tour that is transient, groups that are least enfranchised by the museum’s galleries (and least likely
to know the ‘rules of the game’ (Dawson, 2019) to find the tours) are also most likely to be unable to access this content.

6.4.2 Methodological barriers and challenges

Some museums address this problem of temporality of the tours, and serendipity of coming across them in the gallery, by introducing e-guides (see, for instance, the numbering for an audio tour at the Exploring Space gallery, the content of which is absent in 2019). Broadly, the literature that address e-guides grows out of writings on technological interventions within the museum, rather than literature on guiding. Studies, for example that by Kang and Gretzel (2012), claim positive impact on the experience of visitors because of the e-guides’ flexibility for the visitor (the visitor can start when they want, select the artefacts they want), and the benefits to the museum (seen as being ‘innovative’, not having to manage guides), while acknowledging that the impact of the e-guide is significantly correlated with how confident visiting individuals are with technology in general (a group that may well intersect with those who are least confident in the museum space to begin with). This means that in discussing the use of e-guides, methodological challenges about locating particular knowledge content that might subvert the power dynamics of the museum remain out of reach of the visitor who merely is in the gallery. Rather, I see the use of e-guides as a way of circumventing concerns about how content can be accessed, not the content of the galleries themselves. Additionally, while some museums make tours available and free online (for example, at the Museum of Modern Art, New York), there are many where the audio guide is only available by borrowing it from the museum (e.g. the Royal Academy, London), often for a cost, creating a different but still significant barrier to the information.

Macdonald (1998) describes the power of objects to construct what is ‘knowledge’ and/or appropriate in the science museum space. Tours, more often than not, are tied to the objects within the gallery space (Gammon & Mazda, 2003; Holgate et al. 2002; Pes, 2002). It may be that they draw attention to the absence of artefacts (Miles, 2018), the
slights of textual interpretation (Saggar, n.d.), alternative attributions or stories of the artefacts (Okoye, 2017), or that they develop a critique of the artefacts on display (Procter, 2019), but at its heart, tour material is framed by the galleries they pass through. This means that tours are, by necessity, constructed relationally to what is in the space already – even if their work is to demonstrate exclusions.

This is something that the Science Museum, London, has recognised, and sought to address through its 2005-6 tours around the non-displayed collections of the Museum at Blythe House. In Caeser’s 2007 paper about these tours, two salient concerns stand out. Although there are artefacts that are not in the museum at the stores, and these different pieces introduce new materials for new narratives; these tours appear to be run (or at least developed) by the curators, who are at least in part responsible for the curation of the museum galleries too. This may mean that similar narratives to those already on display at the museum reappear on these tours. Secondly, Caeser reports some of the same challenges to access as described in the points above. There is the limitation to temporal access to the information (and, in this case, artefacts too) and there are limited numbers of visitors permitted on each tour. Furthermore, the visitors who did attend the tours broadly reflected the Museum’s South Kensington adult visitor profile (average age 45-65, high income, 63% male identifying, 88% from London, Greater London or the Home Counties (Caeser, 2007)). We may at least begin to suspect that showing objects in store alone will not remedy the exclusion of ‘progressive’ or ‘controversial’ narratives that could be told by other objects in the gallery space.

As a selling point (as with galleries themselves), tours are often themed. Around London in the past two years, there have been LGBTQ+ tours (Victoria and Albert Museum, Science Museum, Tate), decolonial tours (The Uncomfortable Art Tours, various locations; Victoria and Albert Museum), Black history tours (Tate), repatriation tours (Natural History Museum, London), women’s history tours (Victoria and Albert Museum). This ‘thematising’ of tours presents dual challenges: the tours are separate to the canonical material in the gallery, and therefore the location for such material; these
themes are each separate to each other. I have encountered problems in perceptions of inclusion of those with intersecting identities, where there have been ‘expectations’ from members of the public as well as museum staff about what material would be appropriate in the tours. Conversely, drawing on critical whiteness, we could also question the types of tours that are named and ways they are named. For example, although many of these tours are centred on identities, there is no ‘white men’ tour. By calling out ‘different’ identities in these spaces, we can think critically about how such interventions continue to reinscribe who should be subjected as ‘the Other’ within the gallery. Even though the tour process may break down these subject creations (as discussed earlier), I argue that they simultaneously continue to create differentiated subject groups as they delineate that the proper place for the ‘alternative’ history is in a transient tour.

### 6.4.3 Creation of the subject

Positive aspects of tours cited by museums, scholars and fellow tour guides include that guides can adapt their material to the audience. Indeed, one of Best’s findings is that “tours are not pre-scripted monologues”, but that “tours are best viewed as being interactive and shaped around the moment’s unfolding challenges and opportunities” (Best, 2012, p.47). Curran (2019a) explores this well in describing the spontaneity and reactions in the moment encouraged in their guiding:

> In the notes I received prior to being a tour guide for the National Trust’s Big Brother take over, it recommended that our delivery should be ‘enthusiastic, but tongue in cheek’. (Curran, 2019, p.147)

Combining these findings with professional work on engagement, I believe we can also read Best’s “challenges and opportunities” to include not only the questions asked (or not asked), but also to consider how tour guides judge their audiences’ comprehension, base knowledge and engagement. While there is every possibility that the diligent, considerate guide will ask their group about the knowledges they bring to the tour, there is also the
very real probability that guides can continue to make racist, sexist, classist or homophobic assumptions about what their audiences want to hear and adapt their material accordingly. For instance, in understanding the work of tour guides on plantation sites, Potter notes that “the level to which slavery is discussed is ... guide dependent” (Potter, 2015, p.256):

the extent and type of information guides offer on slavery can often be something they adapt based on the composition of the tour group and the questions audience members pose. Just as guides are adjusting their tour based on the reactions of the audience (silence, questions, facial expressions, and laughter), they are carefully reading their group formulating assumptions about the perceived level of interest in the topic ... [one guide] provided more information on the topic of slavery depending on the racial composition of his tour and what he assumes the group would like to hear. (Potter, 2015, pp.256-7)

In particular, Potter notes that guides report changing the stories (e.g. Gone with the Wind-style narratives, balanced narratives, Afro-centric narratives), changing the word usage (e.g. inclusion of the term ‘Negros’) and developing the performativity of historical empathy depending on their audience composition. Whilst this is a single study of plantation site tour guides, it would be remiss to assume that the reshaping of tours in response to the guide’s perception of a group’s needs or desires are isolated to the sites of plantation tours.

Butler suggests that “structures of power condition and shape social actors’ performance” (Butler, 1990), which I would argue we can see manifested as guides altering their tours in response to the perceived power that the visitor irrevocably shapes the interaction. However, in (re)centering the visitor’s experience, the power of delivering/withholding information to the group on the tour also resides with the tour guide, thus enacting their perceptions of appropriate information and perpetuating perceived power relations
within the gallery space even if the tour covers material often broadly constructed as ‘hidden’ stories.

Critically for thinking about what information might be withheld, tour-guiding to access such knowledge also (co-)creates the guide as expert (de Stefani & Mondada, 2017). As I have previously covered, the tour guide is positioned in the tour as the expert who selects what is appropriate for which audience; this ‘expert’ only appears to be present for a short period of time and is constructed as the one who interprets the objects on a tour. In addition to these concerns, Macdonald questions to what extent “visitors to an exhibition define the exhibitions on their own terms” (Macdonald, 1998, p.4), a question picked up in Dawson’s work, asking how the resources visitors have can be drawn upon to help them access the galleries (Dawson, 2019). Requiring a tour guide to illuminate thematic ideas about racialised individual, genders, sexualities, class or (dis)abilities that are not present in the gallery itself can be seen to act as a further block to visitors drawing on their own knowledge to interpret and engage with the materials in the museum. Thus, rather than incorporating these narratives within the main body of the gallery, working towards visitors interpreting the gallery on their own terms, using their resources and seeing these narratives in relation to constructing their own identities or interpretations, a tour guide presents a ‘sanctioned narrative’ for the visitor that ‘should’ be accepted by virtue of the guide’s perceived expertise.

6.4.4 Summary

In sum, whilst it is possible to use a tour to provoke ideas about the content and narratives beyond the gallery for visitors, there are a number of additional, problematic barriers that sufficiently isolate the information in the tour. I have demonstrated in my tours and more generally that there are practical problems about this mode of delivery: temporality of the tour, how long the tour runs for, barriers to access on time and location, and the cost of running it (emotional, economic, time). I have also shown that there are methodological problems with tours. The tour format in general suffers problems of making the
information appear to be ‘extra’; it reinscribes barriers to access, and retains and reifies the position of the ‘expert’ and is normatively constrained by the objects on display even if the intervention is to highlight exclusions in the space. The Queering the Science Museum case example highlights methodological tensions around keeping or disrupting narrative unities in galleries and also retention or rejection of normative narratives that are proffered by the museum galleries. Finally, on a theoretical level, substantial work is done on the making of subjects in the museum space by the intervention of the tour. This happens both in the construction of the tours as being ‘additional’, thus remaking the Other (both as an insider and an outsider), and through the way that the guide can deliver or engage with the material and the participants in different ways at different times.

6.5 Summary

In this chapter I have made three claims, which I have developed in relation to the case example of the Queering the Science Museum tours, which I have situated both within broader STEMM interventions in museum galleries and within LGBTQ+ interventions elsewhere in the UK. I have described and considered the Queering the Science Museum tours and how they draw on Winchester’s (2013) work on thinking about interventions in art and socio-historical museums. I have then demonstrated that the tours allowed a fourth mechanism of ‘Queer Critique’ for engaging with queer approaches to STEMM in public domains. Finally, I have considered limitations with the Queering the Science Museum tours, as well as the tour format more generally, along theoretical, methodological and practical axes. In sum, echoing Smith (2006b), heritage – scientific or otherwise – is not something that ‘is’, but rather something we do. By challenging the representations, the ways that these representations are developed, and crucially the mode in which we expect to receive these narratives, we are able to challenge and change the work narratives constructed around topics. In the next chapter I shall reflect on the ways that we could challenge these narratives using curatorial dreaming practices.
Chapter 7: Conclusions

Throughout this thesis I have highlighted the ways that permanent gallery spaces in London develop, hold, and continue to deliver narratives about space science. Across the thesis, I have centred a queer feminist methodology, approaching the sources, methods, data, and analysis with a view to thinking critically about how they create and display gender identity and sexuality, and, more than this, other issues to do with equity and diversity too. In this final chapter of my thesis I pull out the conclusions I have drawn across my thesis and organise them around the four central themes that have emerged: the exercises of power in the museum, the role of making western scientific knowledge ‘universal’, the importance of critically interrogating who is represented and how; the new avenues for exploration that a queer feminist approach opens. I have chosen not to structure my conclusions around my research questions – these are not ‘answers’ to the questions I asked – nor should we suppose that those questions can straightforwardly be answered – but rather the questions scaffolded my exploration of the galleries through grounded theory and thematic analysis methods, and have been generative in developing the conclusions that follow in this chapter. After drawing together the strands from across my thesis in each theme, I indicate further avenues of study that my research directs to. The chapter closes by reflecting on my thesis, and doctorate, as a whole.

7.1 Power

7.1.1 Conclusions from my thesis

In my methodology I demonstrated how a queer feminist approach allowed me to understand that power in the museum space is in a state of flux and negotiation between the knower, the subject and their situated relationship in the gallery space. Queer feminist approaches particular understand that the experience of any given visitor is mediated by
their relationship to the materials in a temporal and social context. This idea was explored throughout the thesis, looking at experiences possible in the content of the permanent galleries experienced in isolation (Chapters 4 and 5) and the (re)making of the space in guiding on the Queering the Science Museum tours (Chapter 6). Throughout these chapters I explored not only what is present in the galleries and the tours, but who is implicated as the audience as a result. I explored the ways that queer feminist methodologies can be used to think the situated relationship of the material in the gallery and the power it exerts on the knower in the gallery space.

To structure my thinking about power, I used five questions from my Introduction to investigate the construction of sites of power (Section 1.3), and how they are operationalised in the galleries. I thought throughout the thesis about who is doing science and addressed not only who was represented (Section 4.1) but also how they were included. I demonstrated how exercises of power are constructed, for example, in the language used in describing them (Section 4.1.2) and in their own descriptions of their work (Section 4.2.2). I explored how the galleries frame what is science, particularly focusing on exercising power over erasure of geographical locations (Section 5.2). Queer feminist questions expanded on asking about ‘who’ and ‘what’ by allowing me to focus on who is deciding what is ‘science’ and who is doing ‘science’ too. For example, I demonstrated that the decision to ‘make place’ is an exercise of power that values particular knowers as constructors of the epistemic knowledge that is ‘science’ (Section 5.1) and thought critically about which particular worldviews are empowered in the gallery. I also detailed how the choices around who ‘does’ science are stratified and that particular types of people and positions were marginalised in the galleries (Section 4.1). Finally, I addressed the construction of being and knowing as simultaneous actions in the gallery. In particular, I looked at ways gendered and racialised views were seen and done (Section 4.2) and then were able to be reproduced in the gallery in seeing and doing the same actions in exemplar gallery games (Section 4.3). Across the chapters on space science galleries I demonstrated that displaying a ‘future’ in these galleries is an exercise of
power, constructing heteronormative futures based on an idealised, white past (Section 4.2.3; Section 5.1.3).

Power is particularly exercised in relation to the identities in the galleries. I concluded that there is an emphasis on the importance of people depicted in the galleries through how they are named in the galleries (Section 4.1), showing that those deemed more important in the galleries were vested power by being named by their last name only. I showed how power is exercised by showing gendered relationships between women and men as scientists that reiterated Flicker’s observation in films (2003), and through selecting images that address the view to the objects women are working with/on rather than them themselves (Section 4.2.1). I also drew the conclusion that power is only exercised to describing white, educated, affluent western women – there is little done in these spaces to introduce narratives of other women; where they are, the women are disempowered: there are often no names, professions or other information. I indicated that this was different in more recent temporary galleries (Sections 4.2.1), where more women were empowered to be named alongside their work, but that this division also develops the idea that there are ‘appropriate’ places to name and celebrate women of the past. I draw this through to the ways that the Queering the Science Museum tours suggest that these narratives also sit outside the hegemonic science museum gallery (Section 6.4). Across Chapters 4 and 5 I demonstrated the way that NASA is positioned in power in the Exploring Space gallery, and that considerable effort is also made to closely link Britain’s space work with NASA (Section 4.2.1). The actions in the representation do the dual work of creating the power of NASA and aligning Britain with that power over and against other international agencies – including the European Space Agency to which the UK contributes funds. These binarized and unequal representations were not only present in the ways that the gallery displays identities, but were also reproduced in the content of the spaces and opportunities given to visitors to engage with the process of making knowledge in the gallery (Section 4.2.2).
In Chapter 6 I challenged the hegemonic structures of power in the museum by conducting and theorising about an activist intervention. I explored how the use of queer methodology in relation to the collection allowed a challenge to the power of the museum in dictating how the collection should be understood (Section 6.3.2). In this section I not only concluded that using queer can help us reject binarized ideas of ‘in’ or ‘out’ of the collection, and allow plurality in seeing how objects function, but also highlighted how looking at these objects illustrates the power of the museum in collecting the past, as implicated in the privilege of collecting objects. In the chapter I also demonstrated that using a queer feminist methodology can allow us to renegotiate who are the foci of stories in understanding objects, by shifting the understanding of who is important in the story of each artefact (Section 6.2.2). Finally, I discussed how the tours not only created space to challenge the power of the museum to describe the function of the artefact, but showed how during the Queering the Science Museum tours we worked to reject the power of the guide as the authority of the meaning making, instead decentring and inviting contributions from the attendees, emphasising the collective experience of empowering the subject-participant over the understanding the collection in isolation (Section 6.3.2).

These contributions to understanding and unpacking the power of narrative creation in science and technology museums are novel, as the vast majority of activism on LGBTQ+ heritage has, to date, been situated in arts and socio-historical museums (Section 6.1). However, many of the same structures of power exist across any type of museum institution including the power of describing the relationship between the knower and the material in the space, and queer feminist activism can act to reveal the plurality, subjectivity and contingent nature of the knowledges that are and can be represented in these spaces. For instance, the Queering the Science Museum tours gave power to the tour participants to reject the narrative unity of museum exhibitions – by instead drawing together different stories and histories that moved across the space in a non-sequitur’s manner (Section 6.3.1).
However, the roles of institutional power are still visible even within this challenge to the museum’s narrative. In Section 6.4 I explored practical limitations of the format (for instance, timings, the number of people on the tour, the perception of the work being ‘age-appropriate’), and by the choices the guide makes in what is deemed suitable for the audience in that time and place. Most importantly, perhaps in trying to challenge the content of the museum, the tour upholds the hegemonic power of the museum but secreting the content of the ‘theme’ as being outside what is appropriate within the museum’s ‘official’ narrative.

7.1.2 Further research on power in the STEMM museum

There is significantly more work to be done on understanding the roles, exercises and disruptions of power within STEMM museums. I gesture to some areas that are of particular interest to follow on from the findings of this thesis.

I have particularly thought about the powers in permanent galleries and a single temporal intervention, but I believe research on the roles of other spaces and temporal constructs in these museums utilising a queer feminist methodology would expand the understanding of the many ways that institutional power can be understood. In particular, work on temporary exhibitions as well as other non-gallery sites of the museum would be of interest to this work. In queering the idea of the ‘museum’, a focus on liminal spaces such as the shop, the toilets, the infrastructure or the café would also help understand the exercised of power. For instance, while most museums and galleries have binary gendered toilets, what (if any) transformation does restructuring these facilities permanently, as has been done at the Wellcome Collection (Gender Neutral Toilets, 2020), or temporarily at an evening event do to the types of power the museum describes? In the age of reproducing pieces from the collection in the shop, such as USA-flag holding astronaut Christmas tree decorations at the Moving to Mars (2019) exhibition shop, what additional power are objects given when they are reproduced on post cards or as play-things? What narratives are elevated, which identities and fields are centred, and how does this
challenge or feed into the power structures of the museum? Moreover, what is the feedback of power into decisions that are made at the level of policy, research, or in formal education curricula by the informal curriculum of these national galleries?

Rather than thinking only about the spaces in which these interventions happen, it would also be possible to investigate the challenge or reproduction of power through other temporary interventions in the gallery space. For example, are the roles of internally produced materials such as digital guides, museum activities, or take away games different? Do they challenge and/or uphold power structures in the same ways that external activism could or does?

While I have focused on the materiality of the collection in the gallery space, most museums and heritage sites are working to digitise their collections. In the case of accessioning new vibrators to a collection, which stories are collected along with them, and how can their early use on or by women be moved from medical literature (e.g. Maines, 1999)? What has been the role of the archive in prioritising particular stories and uses of artefacts in the collections? What power is exercised around deciding how to prioritise collecting, and how are ethics and community considerations understood and engaged with? In moving these to the digital archive how could we introduce queer plurality of understanding these objects? Can many narratives about an object co-exist? How, as Clelow (2020) demonstrated, might keyword choice shape the perception of an object on a museum database? How might power be devolved or reshaped in this process? What is the role of power in describing how an object should be ‘properly’ described, tagged, or imaged and understood in a collection, and, of course, who wields that power?

Considering who operationalised this power is also valuable. Further research on how to empower those ‘outside’ or ‘on the fringe’ of groups traditionally empowered by sociotechnical heritage would be important. In focusing on ‘outsiders’, there is the possibility to use a queer feminist approach to the subject matter as well – thinking about content on the periphery of traditional narratives as well as communities, for example,
how the London Transport Museum collects evidence of graffiti on the network. What could decentring power and bringing such groups in facilitate? The power of collection is also important to challenge and critique; what, for instance, might collecting and displaying artefacts around activism against science institutions do to shape narratives? By collecting these objects, such as costumes worn at Pressekonferenz der Tiere and placards against energy generation in an Energy Gallery (On/Off, 2020), is there a process of defining which interventions are valuable and valid through conferring the objects from this activism power and status within a science museum collection? Who does this bring in as visitors and who might this further distance?

More than just thinking about people outside the museum community, greater understanding of the distributions of power within the institution would be invaluable for understanding the meaning making and knowledge construction that happens in the museum. Of interest to me would be challenging the sources of this information – in line with Motto (2016), valuing perhaps the museum educators, guards, cleaners, volunteers and other front-of-house staff. What are the structures of power in the institution that shape, direct, dictate or stricture their work? How can workers in these positions challenge, subvert or reject the directives of those more traditionally seen as ‘in power’ in museums? How do these people shape the narratives of the museum as perceived by visitors? What power are they granted by those visiting the spaces?

7.2 Knowledge as universal

7.2.1 Conclusions from my thesis

By focusing on what has been included in the collections and displays of science and technology museums, I have used a queer feminist methodology to think through what knowledge is created, prioritised, and included in space science. I have shown, and will review here, how collections are presumed to represent a ‘universal’ idea of science; and
how, in constructing a collection in this monolithic manner, the very idea of a ‘queer’ tour suggests that these themes sit separately and outside the ‘proper’, ‘universal’ knowledge of the museum (Section 6.4).

Taking a queer feminist approach allowed me to unpack how this idea of universality is constructed and disseminated. I showed that it happens in relation to human society in a range of ways: from implying a universal (and arguably, nationalist) experience of being in space through only showing foodstuffs common to the USA and the West more generally (Section 4.2.1), to predominantly centring the stories of white men of science (Section 6.3.2), through to positioning British exceptionalism in originating knowledge that was stolen from colonised subjects (Section 5.2.5).

In particular, I looked at the way sites of knowledge creation that sit outside of this western narrative are overlooked in the galleries. I described how Mauna Kea is historicised through photographs and decontextualized through photos of the UKIR observatory (Section 5.2.1), eliminating space for Indigenous Knowledge claims. Similar actions happen in relation to the test launches in Woomera where ‘empty’ land is occupied, displacing Indigenous peoples for rocketry, a narrative which is subsumed under an affective centring of Britain’s involvement in the launches over the Australian land where they take place (Section 5.2.2). I demonstrated that drawing on western perspectives happens through the visual lexicon of the galleries too, using imagery of the American West and the picturesque to reimagine space as being for ‘us’ (Section 5.2.3). All of these cases are undergirded by a colonial conception of land and resources in the world as to be used – through sample collection, research site, or resource use, which I exemplified through the presence of the Omani meteorite in the Natural History Museum display (Section 5.2.4). Moreover, once these galleries have positioned western knowledge as the way of knowing the natural world, this natural world is then framed in relation to other planets, where Earth is the ‘normal’ and all other geographies of other planets are seen as different or deficient (Section 5.1.1), and made to appear to be places that look like Earth in order to be knowable.
This process is exemplified well on entering the Natural History Museum from Exhibition Road. Greeted by the skeleton of Sophie the Stegosaurus – an almost complete dinosaur positioned to facing me as I walk in – I can see beyond Sophie an escalator that starts from a raised platform that runs up through a model of the Earth on into galleries about volcanoes and earthquakes. All walls are slate black, with white paintings on each, illuminated by lights from the top of the space. On the right are paintings of Mars, Jupiter, Saturn, Uranus and Neptune which appear to ‘orbit’ the Earth model in the centre of the gallery rather than a Sun – co-opting the heliocentric plan of planets and mapping it around the Earth. On the left wall are constellations drawn with dashed lines between the stars, linking stars into patterns that are close in space from looking at them on Earth, but which are far apart in space. The dashes are of about equal size to the stars which they connect, naturalising them as a part of the natural world, rather than a single way of knowing about the stars. All of the constellations picked out in the gallery are western constellations, including Vela, Columba, Canis Major. While some of these images are part of a zodiac that may be familiar to members of the public (e.g. Taurus), many are more obscure constellations that populate the night sky. A small panel, also printed in white writing onto the black, contains faded information about the northern heavens, the southern heavens – and (although illegible when I visited) had headings delineating ‘The Zodiac Calendar’ and ‘Our Astral Neighbours’. Constellations are not a ‘scientific’ way of understanding the stars – indeed, much effort is made in formal science education to distinguish a constellation, where stars appear close together in the night sky but are far apart in space, from galaxies or clusters of stars that truly are close together in space. To naturalise western constellations then, should be read as an exercise in asserting a dominant and correct way of knowing about the world.

Similarly, the Astronomy Inspires video that opens the Weller Astronomy Galleries, prompts the viewer to “Look up at night. Pick a star, any star”, while presenting star names growing bigger and fading in the projected animation onto the screen – most of which are in Greek or Latin (for instance Atlas, Electra, Primus Hyadum), through there
are some Arabic-based star names that have then carried through to the western system of astronomy and subsequently included in the Astronomy Inspires video (including Heka, Beid, Azha). This again negates the possibility for non-western modes of understanding Outer Space. Not only highlighting naming and patterns from western knowledge systems, it does not leave possibility for understanding other configurations of Outer Space – for example, valuing the gaps between the stars as much as the stars themselves (e.g. Hamacher & Norris, 2009).

I have argued throughout my thesis that taking this queer feminist approach allows the questioning of the unity of the museum narrative that universalises the knowledge of the museum (Section 6.3.1). I have shown this taking place in the galleries, in invisibilising labour that goes into working, naming, and describing the world and therefore obscuring who is given agency, voice, perspective and presence in the gallery, particularly in the context of gendered, racialised, disability narratives that are overlooked and undertold.

### 7.2.2 Further research on universalising STEMM in the Museum

Further research on the ways that science and scientific knowledge is universalised in museums should be undertaken, particularly in relation to cases of public health and environmental work, where it is essential to challenge views that operationalise western knowledge as the only ‘proper’ way of understanding the world. How could including historical work that addresses local and site-specific knowledge (re)shape these narratives? Some of this research, as I have documented through this thesis, already exists. How could it be included in the gallery? What modes of display might facilitate this communication, and can display prevent marginalising this research? Is it possible to make changes to galleries that would challenge the existing narrative?

Changes in historiographic traditions of situating science (and science communication) in the western world alone could challenge this narrative. How else has Outer Space been understood? What do we owe to knowledge systems outside of the West and what might
we have lost? How has that knowledge been transmitted and preserved, and what might this mean for its inclusion in a display?

To challenge universalising narratives in museums, contextual knowledges and well documented interventions could be introduced. Museum studies work would be well placed to consider if and how such displays might function. Who is involved in their creation? Where are they displayed in a museum? What artefacts might they contain? Who are these displays for and what is their effect? Would it be possible to introduce plural histories of scientific understanding of Outer Space without creating a teleology of the superiority of western science?

In addition to the challenges of universalising knowledge, western science is presented as unchallenged and unmediated by human foibles. How could work on presenting failures, mistakes or missteps introduce a challenge to the apparent certainty in these galleries? Ethnographic, sociological and other media work introduce and understand the roles of religion (for example, Mission Mangal’s inclusion of Hindu rites), luck (such as the ‘Lucky Peanut Jar’ and the Jet Propulsion Laboratory), magic (Redfield’s documentation of shrines and rites at and near the Guiana Space Center) – could these feature in museum galleries as a way of challenging the certainty of science? What could displaying research in progress do to shape this narrative? Or highlighting failures of the past to understand that contemporary research might be incomplete? Would introducing the concept of fallibility of knowledge be possible? How might members of the audience understand that, and what might it do to visitor understanding of science or the museum?

7.3 Identity on display in the museums

7.3.1 Conclusions from my thesis
In my Methodology and Methods Chapter I explored what it meant to be ‘represented’ in a museum, and how a queer feminist approach can help us think about the possibilities of these acts. In particular, I explored the possibilities of including those marginalised historically in their contributions to the space programme – occupying pivotal but overlooked roles. Later in my thesis I circled back to this idea in addressing the inclusion of Roberta Cowell in relation to the spitfire, thinking about how we can pluralise the meaning of identities for inclusion in relation to the existing collections (Section 6.2.1).

On the level of the individual, I discussed how the galleries unevenly include people, and explored the lack of people in the Natural History Museum gallery as being representative of a classical understanding of narrative science explanation (Section 4.1.1). I also looked at how there was a significant emphasis on the individual across all of the galleries rather than collective work (Section 4.1.2), and particularly explored the role of how people were named as a powerful way of empowering or dismissing particular narratives. For instance, I compared the way Helen Sharman was named by only her first name with the use of only the last names of most men mentioned in the gallery, and I concluded that naming is operationalised to imply value and prestige. I argued that this was compounded by the ways that those hegemonically perceived least enfranchised by society were most marginalised in these practices of naming, particularly women of colour, technicians, and people of disability (Section 4.1.3). Thinking more on critically evaluating the position of men in the galleries, I argued that men, in general, were overrepresented in the galleries, and were particularly overrepresented in positions of seniority (Section 4.1), and that the men depicted claimed knowledge making actions of practicalities of science compared to women in the same setting (Section 4.2.2).

However, identity formation happened in other modes in the galleries too. I discussed how the implications of nation-making were seen in both reflecting empires of the past on Earth and discussion of building ‘empires’ in space in the future. Particularly I looked at the way the UK was positioned as being a thought leader through people like Newton, Congreve and groups such as the British Interplanetary Society, with the NASA space
programme and US scientists such as Carl Sagan being the natural endpoint for such initial work on space technology (Section 5.1.2). This exercise in building a national identity, aligned with the United States of America in both the space race and the Cold War more generally, can be read as an exercise of power, that I argued feeds into the trivialisation of Helen Sharman’s space flight with the Russian cosmonauts (Sections 5.1.2.1). The construction of being on the side of the ‘victor’ can also be seen in the framing of British conflicts, where the Exploring Space gallery frames the British as non-aggressive in the construction of conflict in India and in World War Two in the galleries (Section 5.2.5). Indeed, the end point of this is the creation of a narrative of excellence in the face of danger in the displays of Tim Peake’s Soyuz Capsule (Section 5.1.2.2). Across these galleries, I argued that the ‘nation’ is empowered through positioning of people who typically benefit in creation of imaginaries around ‘Britain’ – namely, white educated men.

Rather than only focusing just on identities through the representation of individuals, my thesis explores narratives of identity at the level of the ‘Grand Narrative’ across the gallery. I explored the gendered and racialised femininities that are created in the galleries. In Section 4.2.1 I argued that this can be seen in the construction of narratives around Helen Sharman, Lisa Ruffa and Miss French. I argue that these women are narrativized to demonstrate passivity, caregiving, food production and provision, clerical and administrative labour, and that these roles reiterate media roles of women in STEMM in film media. Contemporary figures of research scientists interviewed in the gallery also showed imbalance in their representation, where women discuss ‘doing’ active work in their video slots whereas men claim discovery or knowledge making work of science. I concluded that this finding echoed analysis of print and news media, where there is an equality in the introduction of researchers, but gendered differences in their representation. I also presented evidence of the sexualisation of Black men, and the reification of heteronormative ideals in the gallery (Section 4.2.3), concluding that these further reinforce particular narratives around gendered and racialised identities.
I also worked through the construction of activity and passivity in the galleries and explored the implications of the various ways these modes of science are operationalised in relation to binary identities. I discussed how in the more recent galleries there is evidence of more people talking about the work that they do in science, but a minority of people are actually seen to be active in their research and when they are, it is more likely to be women (Section 4.3.1). I argued that when activity is present, the emphasis is placed on the data through the construction of images and the mode of the text, rather than on the process or the scientist doing the work. Within this, there is further gendering of the ‘appropriate’ activity for particular people. I then compared the ways that activity or passivity were used in two games in two different galleries. I concluded that even when materials in the game fit with a ‘Female Responsive Design’ (which I critiqued) by including collaborative work, a real-world setting, and interaction with other people, there are clear limits to how binarizing these materials can be (Section 4.3.2). I specifically demonstrated this through the examples of showing only white men, and evoking the real world need for the research as being ‘for the good of humanity’, universalising an activity that does not equally benefit everyone as I have discussed earlier in this chapter. I demonstrated that the conclusions I have drawn reiterate what has been argued elsewhere, that “science is the purview of ‘whiteness and maleness’ even in children’s toys – characteristics of space are strongly aligned with boyhood over and above “childhood”” (Onion, 2019) (Section 4.3).

This argument around the types of gendered childhoods that are on display can be seen by thinking through the presence of materials associated with research science. More recent additions to the Exploring Space Gallery, however, conform to the historic pattern of valuing masculine identities though increased visibility in the gallery. Mat Irwin’s models of popular science fiction, commissioned to complement older models that the Science Museum have (Gouyon, 2014a; Millard, 2010), continue political commitment to models (and/or toys) that are tied to masculine ideas of childhood; space ships modelled from Chesley Bonestell’s paintings and Star Trek’s USS Enterprise feed into ideal of masculinity in space science fiction, and fandoms (Busse, 2013; Salter & Blodgett, 2017).
By contrast, for instance, the Technical Museum in Vienna has included, American Girl Doll Luciana Vega, a Latinx astronaut in training and her Martian habitat (No. 100847); the Smithsonian Air and Space Museum has a collection of popular culture astronaut dolls including Miss Astronaut, a 1965 Barbie astronaut (No. A20070121000), and Astronaut Barbie (1985, No. A20070118000). Tim Peake had the ‘first doll in space’, Lottie a stargazer, designed by six year-old Abigail for Lottie Dolls (www.lottie.com, 2016). Lottie was taken to the International Space Station on his flight, and would perhaps have offered an opportunity to challenge which childhoods are featured in this gallery. However, there are many toys intended for use in space that are not taken as exercises in engagement. The Toys in Space programme until 2002 (NASA Education, 2014), and small stuffed toys are used as zero-g indicators – to show astronauts they have reached zero-g by floating in the spacecraft, such as the plush Earth toys use in the SpaceX/Tesla launch (Weitering, 2019). Being critical of which toys, as well as which examples of such toys, are included tells us about the gendered narratives implicit in the galleries – and also the co-construction of racialised, accessibility and ethnic narratives. We should be critical, Morrison argues, of children’s dolls which can be cultural stand-ins for white femininity (Morrison, 1970); ongoing arguments about Luciana Vega make the case that the doll exploits the identity of queer non-binary astronomer Lucianne Walkowicz for the profit of the American Girl Doll Company (Johnson, 2020).

7.3.2 Future areas of research on identity in the galleries

While this thesis has explored the construction of the gallery, further research on identity in relation to the pedagogy of the gallery could look at how the galleries impact visitors’ self-identity being in and passing through these galleries. Are the impacts of the galleries the same? Are the experiences the same for different community groups? Other researchers have demonstrated that visiting in school groups or in family units shapes the interaction and performances in the gallery spaces of science museums (Godec, 2020); to what extent could the same effects be seen in visitors to the galleries in this case study?
Who has their identity affirmed in these gallery spaces? Other areas of STEMM museums might be perceived to be less gendered (for instance, narratives around medicine); can a measurable difference be understood in terms of gender performances in space science galleries as compared to other galleries? How could access to further archival materials about audiences to the museums at the times these galleries were constructed (for example, historic interviews with visitors; internal visitor studies projects) shape the understanding of who the galleries were aimed at (Dawson, 2019; Dawson & Jensen 2010; Falk, 2016), or how the galleries were conceived in the first iteration? How do the (perceived) needs of the population (and who constitutes this population) change over time and by geographical location?

Having explored the gendered ways the gallery can be understood, further research in museum studies areas could address what innovations might facilitate changeable displays in the galleries to address some of the problems highlighted in this thesis. Research might seek to understand the possibilities of digital work, material interventions into the galleries, or production of education projects to be situated within the galleries. How could more permanent interventions challenge or reshape the narratives within these spaces? What is needed for museums to be able to make such changes or interventions in a sustainable way? What other constraints within the dynamics of the museum are shaping the practicalities of doing such work?

Finally, challenging who is able to be included in the gallery requires historical research on the actors and networks that are present in the space science field. Inclusion requires detailing the presence in the archive or recording narratives that have been left out of the gallery and bringing these perspectives together. It is imperative that we ask questions about who is being included and how these voices are valued – what ethical considerations are being enacted to shape these projects? Where is the space for dissenting voices? Whose perspective is still absent from this new research, and what can be done to challenge that gap? Historical research with, for example, technical workers, or Indigenous populations can introduce new spaces and voices – but how else are we able to
challenge the hegemony of the archive as a tool? What artefacts (material or digital) are deemed appropriate for storage? How/Could invaluable intangible heritage about sky cultures be collected and displayed? What do, or should, we have access to?

7.4 Queer feminist methodology in research praxis

7.4.1 Conclusions from my thesis

I have furthered the application of queer feminist methodologies to museum research. In this section, I will demonstrate the benefits to my argument that my approach has made, as well as specific innovations that I have made to research in science and technology museums and in museum activism.

I have detailed in my Methodology and Methods the importance that queer feminist approaches give to me thinking about myself as the reader and knower in the space – seen for instance in my adaptation of my methods to focus on the ‘situated’ relationships within the galleries rather than objects individually (Section 3.2). This approach encouraged me to view research as part of being and knowing outside research, as well as queering the ‘end’ of doing research against the continuous development that is possible as a researcher.

I particularly made the case that there is an innovation in the Queering the Science Museum tours that moves them beyond LGBTQ+ to ‘queer’, allowing access to situated criticality, and presents a challenge to the ways of doing the work, not just to the stories that are told about the past (Section 6.3). These values came through in the arguments I have made around queer historiography and the ways I presented uncertainty of history as the end point rather than dismissing it in the search for a final ending to stories (Section 6.2.1). Similarly, I demonstrated a challenge the ideas of binarizing gendered ‘traits’ in science learning and knowledge types. I argued that this idea can be challenged both by
demonstrating that multiple knowledges are important, and by drawing on queer to reject
the idea of ‘binarising’ these traits in the first instance, and to reject even trying to
understand them on a unidimensional ‘scale’ stretched between ‘creative’ and ‘rational’
(Section 4.3).

Through these, and other actions, I argue it is possible to make space for queer lives at
science museums (Section 6.2), giving understanding, perspectives and space to be visibly
queer and scientific. It is paramount, therefore, that this is an expansive understanding of
inclusion – centring only the voices of white, gay cis-men, for example, is insufficient. As
well as this, I argued that my queer feminist approaches opened spaces in the galleries to
reject the narrative unity of the gallery (Section 6.3.1) both on the tours, and more
generally across my thesis. This further allowed me to challenge the normative practices in
science, using queer, for instance, to focuses on better understanding the norms of those
included, and thus who (and what structures) are ‘outside’ the museum. My thesis
demonstrated that using a queer feminist methodology helped me map activist projects
from sociohistorical galleries into the STEMM heritage space of the Science Museum,
and further highlighted that the tour was an insufficient intervention into the hegemonic
narratives of the museum (Section 6.1).

7.4.2 Further applications and work with a queer feminist methodology

Further work in my research praxis is thinking with greater clarity about what embedding
‘queer’ deeper into the methods that I have used would look like. Whilst I have collected
data using the research methods in Section 3.2, it was more straightforward to implement
a queer feminist methodology into my analytic work than to envisage what queer feminist
informed data might look like, once collected through the chosen methods. Browne and
Nash (2016) argue that this is a problem across queer research. However, they maintain
that a shifting in discourse from ‘what is queer theory?’ to ‘how is queer theory done?’
(Ghaziani & Brim, 2019) and exploration about what queer methods (or, in this case,
queer feminist methods) might look like (e.g. Queer Method quoted in Brim & Ghaziani,
2016) is underway. Thus, taking these questions about queering methods and the data produced would more deeply embed ‘queer’ in my data collection practices as well as my data analysis practices. What do queer feminist methods look like? How might they change the understanding of data? Is the understanding of data that permeates this thesis – something collected from the world that can be kept, static, and used in analysis – compatible with what queer feminist methods might generate as data?

Whilst the application of this methodology in my thesis was the science museum media, further research could think expansively about the media used to construct and narrativize Outer Space in the public domain. This would include critical engagement with content such as film and TV, podcasts, radio, news media, fiction and non-fiction books, art and videogames. Approaching these with a queer feminist lens will help challenge the gender essentialism that arises in some analysis of Outer Space. Who is included? How are they represented? Is there space for non-conformity to the expectation, or is this non-conformity somehow trivialised or made light of? How are narratives about who can work in or be in space science changing with time and geography? How do they fit into broader social trends, such as the rising depictions of scientists of Colour in TV shows like *The Expanding Universe of Ashley Garcia* (2020), or other movements in formal or informal education?

Moreover, rather than just thinking about popular media production outside of the space science field, could utilising a queer feminist approach in critiquing or challenging media provide a road map or call to action to, for example, space science agencies or industry bodies about the ways they represent their organisations? This is particularly important when thinking about the circularity of representation, that the choice of people promoted by organisations (for press, in images, in public relations work) shapes those that are then chosen to represent the field, which reiterates the possibilities of who can be in that field. How could this approach help to find ways to pluralise representation? What might queer feminism methodologies gain from being embedded as praxis in international science and technical organisations?
Focusing more specially on museums, to what might a queer feminist methodology direct work in a science and technology museum? In the display of Sally Ride at the Smithsonian, a nod to her partner Tam O’Shaughnessy was in their tennis rackets – what knowledge is required for members of the institution, or members of the public, to see this queer narrative? What tensions are inherent in such displays? How do they empower or lock out knowledge for the viewer? I have already demonstrated the emphasis on situatedness in the museum and thinking about the galleries as a whole rather than as an assemblage of objects; I believe the same approach would guide thoughts on thinking about the museum as a whole rather than a collection of galleries. Looking holistically, can queer feminist approaches help think through choices made in physical science museums? For example, the *Who owns PINK?* (2019) exhibition at the Technisches Museum Wien highlights the roles of colours in physical science equipment, but can queer feminist approaches also help to critically engage with shapes and design too? What is the role of things that do not ‘fit’ the museum, that are problems by virtue of their aesthetics, for a technological narrative? How could these reflections be operationalised to think about future collecting? Where are these collections documented, how are they documented and by whom? What influence does the individual curator have within an institution to challenge or change the collecting agenda of the institution? What are the limitations of these efforts by workers? How are (activist) projects outside the museum institution viewed by and in relation to the institution?

Finally, focusing on my praxis as an urgent part of my queer feminist methodology, future research should not only focus on the research that can take place from afar, but also the engagement that can happen close. How can my queer feminist research feed into and develop from activist practice in the museum sector? How does research, such as this thesis, (re)shape my teaching of science communication, of science, or of museum studies? What is the impact of doing teaching on my research practice? How else does this queer feminist methodology shape my praxis in, for example, communication of my work.
or event organising or practice in meetings? How can I understand my own work better and productively theorise about the implications of my praxis?

7.5 The End?

I started this thesis thinking about the presence of a Make-up Kit in a gallery about astronauts and space science, and working out how to think through what the relational presence and absence of artefacts, images, texts, and gallery designs bring to bear on the knowledges and narratives constructed in a museum space. My thesis has taken a route through thinking about a queer feminist methodology and explored how this informs questions that I ask of the gallery and the methods for data collection and analysis that I use as well as their limitations. I presented my data and discussions about the ways people and science are presented. I explored an intervention that I conducted to challenge these narratives in July 2018. Finally, I have drawn together the conclusions of this thesis and thought about further research, and questions, that it generates.

The end of writing this thesis has been very different to anything I could have expected it to be. In March 2020, as my writing up was ongoing, museums, galleries, universities, education institutions and places for social gathering closed around the world. The final version of this thesis is in part shaped by that close – research and writing that may once have felt vital, came to feel less urgent; other projects grew in importance. I organised a digital conference, Space Science in Context, that emphasised decolonial, contextual, critical approaches to space science, and these directions in my research make themselves felt in parts that I revised later in my writing. I also wrote alone, lived alone. I kept only digitally in touch with colleagues, writing and working companions, communities, supervisors, friends. This shift has also shaped some of the writing of this thesis, where ideas, thoughts, may have been discussed and iterated with others; I have instead done so alone (at least in a physical sense) – perhaps this will be apparent in the tone of paragraphs, sections, even whole chapters, not only changing the emphasis but perhaps
the discussions and conclusions too. Writing is never done in isolation: grounded in an understanding of iterative praxis, the (social) world around me shapes and shifts the priorities, needs, and requirements of what I write, and what I write shapes my experience too.

As a result, I have started to think about the affective experience of being in the places this thesis discusses, and how those experiences might be communicated. What is it like to be on the International Space Station – far away, isolated, from everyone you know on Earth? Do you experience that isolation while maintaining or operating a telescope in the desert with your colleagues? How does it feel for the experience of your home, your sacred place, or your relationships with your natural world around you, to be under threat, or forever shifted by an external force you cannot control? What does ‘remote’ tell us about our connectivity, our ability to stream data and interact digitally, our dependence on the internet and satellite infrastructure in near-Earth Outer Space? How can we value the social and physical infrastructure, conception and understanding of our world contingent on our relationship with space beyond Earth?

Being and knowing are always mutual. Living and writing my thesis during the coronavirus pandemic has reshaped what I have conceived of as possible avenues for consideration. This shift, this change, has pushed me, this research, and my praxis onwards past the end of writing this thesis into future work, guided by the questions that have come out of my research; and these new thoughts and concerns.
References


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Katriel, T., (1993). “Our future is where our past is:” Studying heritage museums as ideological and performative arenas. Communications Monographs. 60 (1). pp.69-75.


Royal College of Physicians. (2020). Exhibit label, transcribed from *This vexed question: 500 years of women in medicine*.


Appendix A – Examples of completed data collection forms in galleries

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<th>Low Pressure Settings?</th>
<th>Instructions for interactions?</th>
<th>What to do in close proximity?</th>
<th>What type of exploration?</th>
<th>What are the goals of exercise?</th>
<th>Which language?</th>
<th>Label Voice</th>
<th>Other</th>
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<th>Real World Context?</th>
<th>Who is depicted?</th>
<th>Are there role models?</th>
<th>Self-image?</th>
<th>Aesthetic type?</th>
<th>Informality?</th>
<th>Types of skills and interests</th>
<th>Other</th>
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<th>Connections</th>
<th>Conclusion</th>
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<tr>
<th>Visitor Experience</th>
<th>Typographic Design</th>
<th>Production and Fabrication</th>
<th>Location relative to artefact</th>
<th>Location of test panel in gallery</th>
<th>Other</th>
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<td>Examples of completed data collection forms in galleries</td>
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<th>Development/Display</th>
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Appendix B – Queering the Science Museum Questionnaire

Queering Science Museum
Thank you so much for coming to Queering the Science Museum! We’ve had such a lovely month getting to share stories with you about LGBTQ+ scientists and thinking about how we could Queer the Museum using these stories. We hope you all had a lovely time too.

We’d love a bit of feedback on the tours on this form. The feedback will help us with our report for the British Society for the History of Science (as they funded our tours), will be included in presenting this tour at conferences and papers, writing up in thesis, and with planning Queering the Science Museum as part of the perennial tours at the Science Museum. We’re also hoping that maybe we get to do the whole thing again in the near future, and if there’s anything we should have included or changed we’d love to hear your thoughts!
Elle and Damien x

1. Which tour did you come on?
   Mark only one oval.
   - Wednesday 27th June
   - Thursday 9th July
   - Sunday 8th July
   - Saturday 14th July
   - Sunday 15th July
   - Saturday 21st July
   - Sunday 22nd July
   - Saturday 28th July
   - Sunday 29th July
   - Prefer not to say

2. Would you have come to the Science Museum on the day you came to the tour if we hadn’t been running the tour?
   Mark only one oval.
   - Yes
   - No
   - Maybe
   - Prefer not to say

3. When was the last time you came to the Science Museum?
   Mark only one oval.
   - Within the past year
   - 1-5 years ago
   - 6-15 year ago
   - More than 15 years ago
   - I’ve never been
   - I work at the Science Museum
   - Prefer not to say

About the tour

4. What motivated you to attend Queering the Science Museum?
5. What did you think was good about Queering the Science Museum?

________________________________________

6. Did you know any of the LGBTQIA+ stories that were discussed before coming on the tour?

________________________________________

7. Are there other LGBTQIA+ science stories you would have liked to have seen included on our tour?

________________________________________

________________________________________

8. Is there anything you would like us to change about the tour?

________________________________________

9. Would you recommend Queering the Science Museum to a friend or colleague?

Mark only one oval.

☐ Nope
☐ Yeah
☐ I already did!
☐ Prefer not to say

10. Would you be interested in attending more LGBTQIA+ tours or events at the Science Museum?

Mark only one oval.

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<td>No thanks</td>
<td></td>
<td></td>
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<td>Colour me interested!</td>
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11. Have you been to LGBTQIA+ tours at other museums?

Mark only one oval.

☐ Yes
☐ No
☐ Prefer not to say

12. Would you be interested in attending more LGBTQIA+ science events at other museums?

Mark only one oval.

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<td>Probably not</td>
<td></td>
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<td>Count me in!</td>
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13. Do you identify as LGBTQIA+?
   Mark only one oval.
   ☐ Yes  ☐ No  ☐ Prefer not to say

14. How old are you?
   Mark only one oval.
   ☐ Under 18  ☐ 18-25  ☐ 26-35  ☐ 36-50  ☐ 51-75  ☐ Over 75  ☐ Prefer not to say

15. If you’d like us to stay in touch about upcoming LGBTQIA+ STEM projects please leave us your email below.

______________________________
Appendix C – Maps of the Galleries

ii. From the Beginning at The Natural History Museum, London.
   a. Astronomy Questions
b. Astronomy Explores
c. Astronomy Inspires