Graphic Social Futures

Developing Visual Tools for Futures Research

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‘It’s still magic. Knowing things is magical, if other people don’t know them.’

Terry Pratchett (1948 – 2015) - A Hat Full of Sky

Declaration

This thesis has not been submitted in support of an application for another degree at this or any other university. It is the result of my own work and includes nothing that is the outcome of work done in collaboration except where specifically indicated. Many of the ideas in this thesis were the product of discussion with my supervisors Professor Nick Dunn, Dr Daniel Richards and Professor Allan Rennie. Excerpts of this thesis have been published in the following conference manuscripts.

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To say that this PhD would not have been possible without the limitless love and support of my amazing wife Franziska, is an understatement, thank you for being my travelling companion on this journey and all those that follow.

I am eternally grateful to all my friends and family who have helped me along the way, especially my Mum & Dad and my sister, who have always believed in me, even when I didn’t.

A tremendous amount of thanks also to my supervisors and friends Nick Dunn, Dan Richards and Allan Rennie, who have been there to offer guidance, support, and perhaps more importantly patience, throughout this process and beyond.

Abstract

This thesis seeks to understand how social futures research can be used to engage with, and subsequently involve the public in futures thinking. It has been argued that societies shape themselves partly through the images of the future that they construct. However, the creation of visions and visioning is frequently entangled with commercial and business strategy, and as a result often fails to represent the aspirations of a society. Therefore, what is needed are specific tools to help engage the public in futures research, to help guide discussions, and to reveal the existing underlying social structures, necessary to describe alternative social imaginaries.

This research presents a methodology for the creation of graphic social futures, depictions of alternative imaginaries which are themselves socially constructed, using the lens of social futures as distinct from technological futures to engage with the public, to better facilitate discussions around the future of technology and its impact on society. In this instance 3D Printing technology has been used as a driver for change, providing a shared focus for discussions to explore alternative futures.

Social futures is an emergent interdisciplinary field that aims to bring about, analyse and emphasise the ways in which social practices, institutes and social groups are organised and reorganised, by strongly emphasising and placing the social into futures thinking. Through the creation of alternative futures, visioning allows us to explore different options and, as a society, negotiate our values and preferences. Design Fiction offers a way of exploring alternative futures, free from commercial influences or constraints, although, these are frequently influenced and informed by those who are deemed to have 'expertise' – scientists and technologists, political scientists, economists, but rarely wider publics. Therefore, further work is needed in addressing the issue of how to better engage with the very public that this method is purported to be concerned with.

This research contributes to the emergent field of social futures research, through the development and analysis of graphic social futures as a method to democratise the construction and discussion of possible futures. These graphic social futures work by exposing possible flawed futures, and

provoking debate on how things could, or should be, and encourages consideration for how we get there.

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1.0 Introduction

1.1 Origin Story[1]

This research began with the question; why, considering the consistent hype and widespread media attention, is 3D printing not more commonplace? How has this technology, that has for over a decade been afforded all the benefits that a technology needs to succeed, not achieved the level of success, or been adopted by society to the extent that was predicted by the media? As such, the initial attempts to understand and find the answers to this question began by focusing on the technology itself. The assumption being that the technology was somehow falling short of expectations, considering that a relatively high level of technical expertise is still required to setup and run the devices, a contrast to the plug and play devices that are portrayed by the manufacturers and media. Therefore, it was thought that this could be approached as an 'engineering design' problem, which is an established method for identifying a problem that can be solved through design (Pahl *et al.*, 2007; Elgaard *et al.*, 2018). However, early conversations with friends and colleagues revealed that whilst they fully expected to use 3D printing technology in the future, most of their expectations regarding future use cases were all very much possible with the technology that is already available today. This was the moment of realisation that the original question this research set out to answer: *What are the Social Futures for 3D Printing?* is a social science question, one that could not be answered by taking an engineering design approach, it would instead be necessary to treat this as a social science problem. The challenge for these people was not in imagining the technology itself but imagining how the technology could feature and contribute to their own futures. Whilst much effort has been put into the democratisation of technology and understanding its relationship with society, this same attention has not been given to the underlying social imaginaries that explore how this technology will enter our everyday lives.

[1] The term Origin Story is used (most commonly in works of science-fiction) to describe a backstory, or establish background narrative, that informs the identity and motivations of characters, but is used here to describe the motivations behind this research. This terminology is borrowed from pop-culture, which forms an important part of the context for this research, something which is explained in greater detail in Chapter 2.

Unfortunately, unlike the process of engineering design, the process for understanding the adoption of technology does not have an equivalent series of steps that can be taken to identify problems to be solved through design. Specifically, the difficulty came when attempting to identify a process to understand the underlying reasons for 3D printing not achieving the success that it was predicted to have. The successful adoption and diffusion of a new technology into society is a highly complex process, one that is often only fully understood retrospectively (Rogers, 2003; Rotolo *et al.*, 2015), suggesting the need for a novel methodology, for revealing current and existing underlying social attitudes towards emerging technology. This research seeks to understand the process of technology adoption and diffusion as it is currently occurring across society, in real time, to reveal the social impacts that people anticipate emerging technologies could have.

This thesis is the story of how different methods and approaches, adapted from futures studies, design fiction and science and technology studies, have influenced the development of a methodology for the creation of socially informed *graphic social futures*.

1.2 Outline

This research sits within the futures field of study, the plural being used to signify the existence of many potential alternative futures (Voros, 2022). More specifically this research focusses on social futures and is funded by the Institute for Social Futures at Lancaster University. Social futures is a relatively new field of research that strives to move away from futures that are merely presented and discussed as deterministic extrapolations of technology or present events (Urry and Woodhead, 2015b). This research uses a design lens to explore thinking and visioning relating to social futures and uses an investigation into the potential of 3D printing technologies to promote social change as a vehicle to achieve this.

Much has already been written concerning the relationship between technology and society and their mutual influences on each other (Straub, 2009; Bijker and Law, 1992; Bijker *et al.*, 2012). However, research involving members of the public that is concerned with futures and technology, can be problematic, considering that emerging technology is often not something that the public have first-hand experience or knowledge of (Rotolo *et al.*, 2015). This research aims to develop a methodology for the production of graphic social futures, which are themselves informed by the anticipations and expectations of the public, as a tool to guide conversations around futures.

This chapter introduces the study, by first discussing the background and context, followed by the research aims, the research objectives, questions, the research problem, and finally the significance of this research.

1.3 A Brief History of Futures

Futures research emerged as a field of study in the 1960s and due to the vast array of studies and approaches within this field (Börjeson *et al.*, 2006), has been referred to as a "very fuzzy multi-field" (Marien, 2002: p. 263). Numerous names and terms have been given to this area of study (Lopez-Galviz and Spiers, 2021), however, this research simply uses the blanket term *futures* by means of acknowledging the existence of many potential *alternative futures* rather than a singular future. Just as there are many names given to this field of research, there are also many different approaches to the study of futures. In 1981 Amara wrote what he considered to be the three fundamental premises upon which the futures field rests. Voros (2022) later adapted these, light heartedly referring to them as the "Three Laws of Futures", which are:

I. The future is not predictable.
II. The future is not predetermined.
III. Future outcomes can be influenced by our choices in the present.

Voros is perhaps better known for his futures *cone* (see figure 1.3), which is frequently referred to and adapted by design researchers and practitioners. The diagram visualises the four kinds of futures, as previously defined by Henchey (1978: p. 26), these are: "possible futures (what may be); preferable futures (what should be); plausible futures (what could be); and probable futures (what will likely be)”. Whilst commonly referred to as ‘Voros’ futures cone’, the futures cone model was first produced by Hancock and Bezold (1994) (see figure 1.2), though this was done in an effort to visualise the work of Taylor (1990), who described a ‘cone of possibility’ that defined a range of plausible futures, extended over an explicit timeframe (see figure 1.1). The diagrams have been included below and specifically positioned in chronological order, to make clear the ways in which futures thinking evolved over this period.

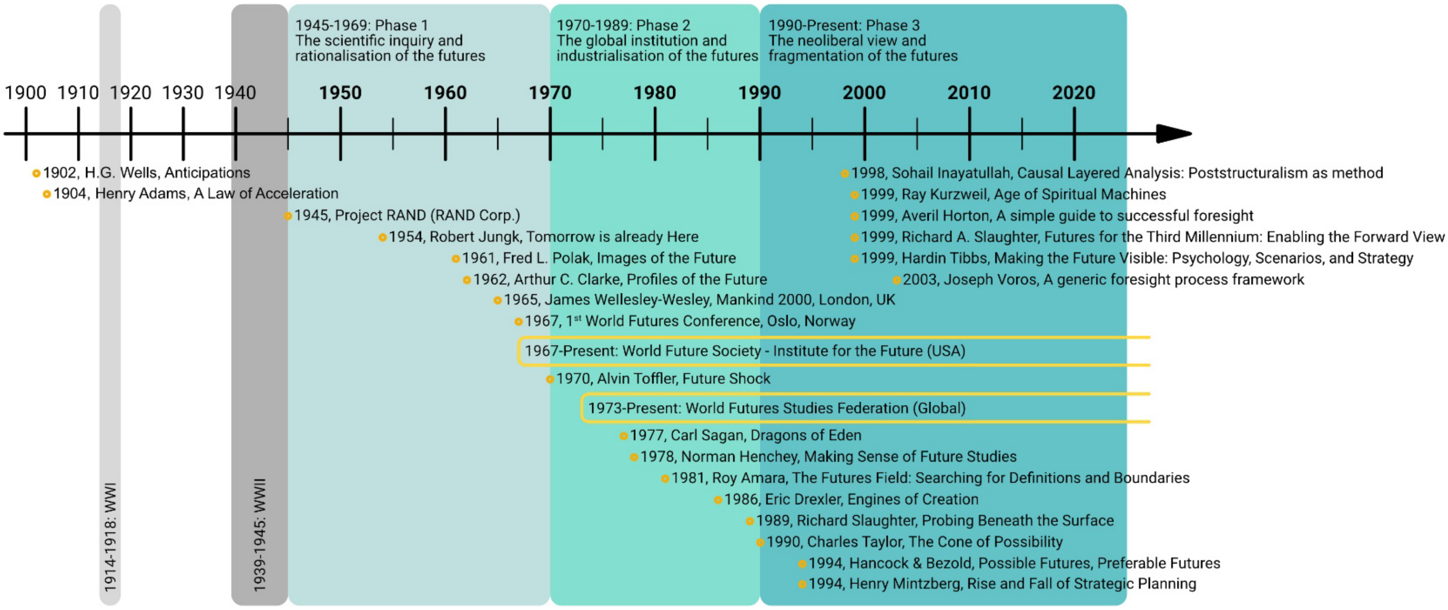


Figure 1.1 Futures Studies Timeline, indicating key publications and events that helped to shape the field of futures research, as described by Hines (2020), Son (2015) and Voros (Voros, 2022).

An alternative approach to the conceptualisation of futures was provided by Slaughter (1989, 1999), who distinguished four levels of ‘depth’ in futures thinking. The shallowest level he termed ‘“Pop” futurism’, which is the most superficial, but also the most prevalent as this is found in most examples of popular media concerned with *the future* (Voros, 2022). The next layer down is ‘Problem-oriented futures work’, which is more serious and looks at deeper issues, to uncover their causes. ‘Critical futures studies’ are the next level down and is more serious again, as this attempts to probe beneath the surface of the social causes of the problems identified by problem-oriented futures work. The deepest and final level is referred to by Slaughter as ‘Epistemological futures work', which deals with philosophy, epistemology, ontology, cosmology, microhistory, the study of time and the influence of consciousness on the human endeavour. This, in contrast to "Pop" futurism, is the level at which the least amount of work is being done (Voros, 2022).

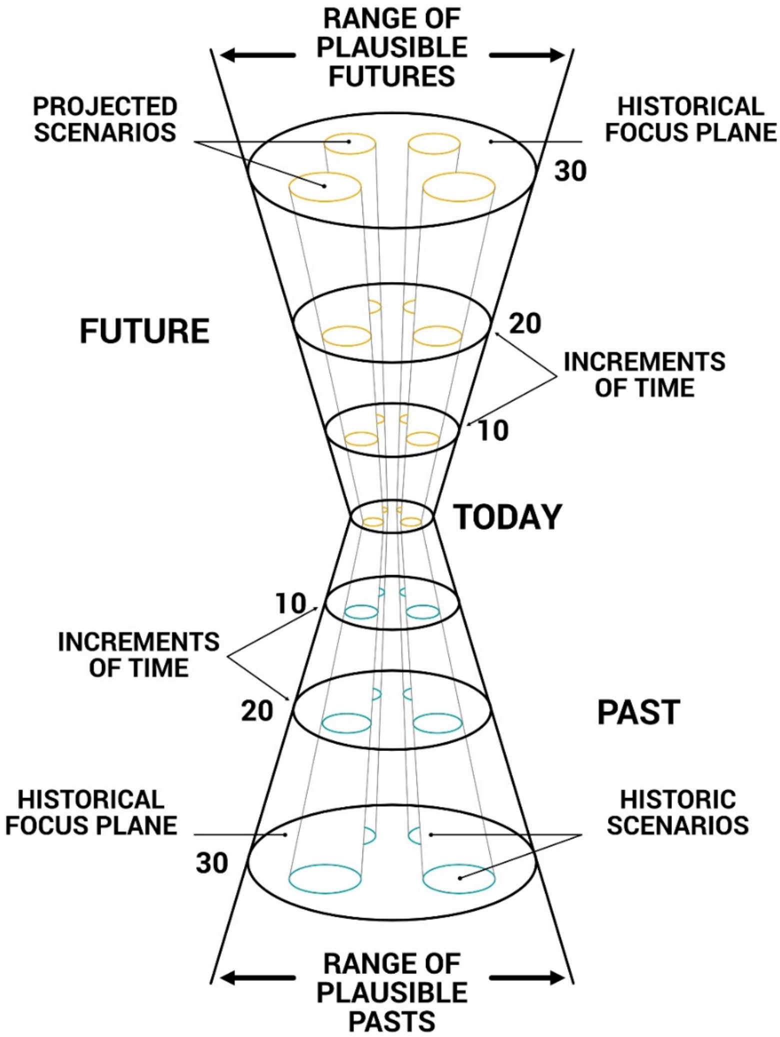


Figure 1.2 The Cone of Possibility (Taylor, 1990) (redrawn by author) – Taylor's original "cone of possibility" diagram defined a range of plausible futures extended over a specific timeframe. The notable difference between this diagram and those that followed is the inclusion of past events, which were absent from later adaptations of this concept.

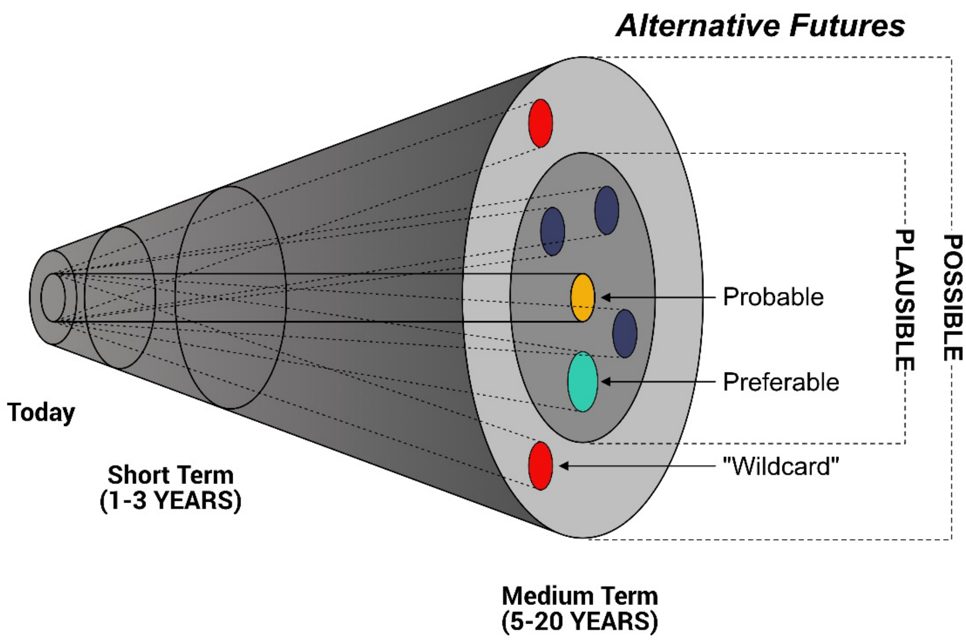


Figure 1.3 Types of Futures diagram, (Hancock and Bezold, 1994) *(redrawn by author) – This diagram illustrates the relationship of the 'four futures' to one another and "makes it clear that all these futures start from where we are today but then diverge". This was an evolution of the Cone of Plausibility diagram by Taylor* (1990)*, but removed the acknowledgment of the past as an influence on futures.*

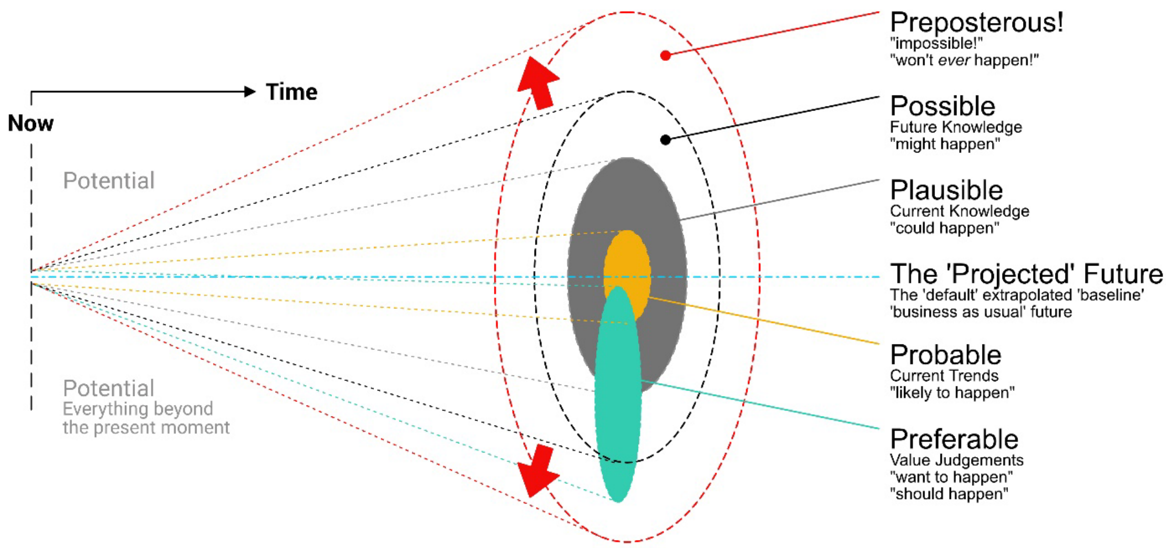


Figure 1.4 The Futures Cone, (Voros, 2017) *(redrawn by author) – Voros' Futures Cone illustrates the variety of possible futures that emanate from any current moment in time. Though this version of the Futures Cone was*

developed by Voros, it was based on the 'Futures Cone' model by Hancock and Bezold (1994)*, which itself was based on the 'Cone of Plausibility', devised by Taylor* (1990)*.*

Whilst the future may not be predictable or predetermined, these methods enable alternative futures to be explored and preferred futures to be imagined. As future outcomes can be influenced by our choices made in the past and present, our images and representations of the future are therefore important tools that inform our decision making. This resonates with the work of Taylor (2004) concerning the *social imaginary,* a concept for how individuals imagine their social existence. This idea is not only expressed in theoretical terms, but is also carried in our images, stories and legends. Importantly, these narratives and images are not only constructed by society, but they can also be highly influential in shaping the future that society strives for (Stein, 2017; Weber, 2020).

Over three decades ago, the futurist Richard Slaughter stated that "there is still far too little futures work carried out explicitly for the public interest" (1989: p.461). As will be evidenced in the literature review (Chapter Two), this could still be considered true today, though notably there are a number of design and research groups looking to address this balance. One such group, who support this research, is the Institute for Social Futures [ISF] at Lancaster University, which was founded in 2015 by sociologists John Urry and Linda Woodhead. Social Futures research aims to bring about, analyse and emphasise the ways in which social practices, institutes and social groups are organised and reorganised, by strongly emphasising and placing the social into thinking futures. In this manner, social futures encourage us to think not only in the interest of our current generation, but also future generations. The ISF is transdisciplinary and as a relatively new focus of research within the futures field, has many different approaches and definitions for what constitutes social futures. The aim of this social futures research is to give a voice to past, present and future societies, considering that "It is from the viewpoint of persons in the world (rather than academics and researchers in ivory towers) that we achieve true communication" (Slaughter, 1989: p.447). This has been a challenge for futures studies and something that Slaughter has himself strived for, his ultimate goal being for futures studies to enable the development of 'social foresight' (Riedy, 2021).

Whilst the means of creating strategic foresight, aptly named *future visioning* (Slaughter, 2002b), is an established and well recognised method for speculating on the future of technology, much like futures as represented by mainstream media, future visions can also succumb to their own hyperbole. A new design paradigm has emerged over the past decade that provides an alternative to these future visions which are primarily constructed and driven by corporations and media hype. *Speculative design*, and more specifically *design fiction*[2], offer a platform for exploring unknown unknowns, working through alternatives, and contesting the status quo. Dunne and Raby, who ran a Design Interactions programme and pioneered the use of critical design, described how speculative worlds created in this manner avoid predicting futures and instead explore alternative scenarios, as "although the future cannot be predicted, we can help set in place today factors that will increase the probability of more desirable futures happening" (2013: p.6). One of the benefits of design fiction was its freedom from commercial constraints and agenda, being not concerned with promoting or predicting futures, but is instead concerned with highlighting the possible, and envisioning the possibilities that could, and perhaps more importantly, should manifest. Despite this being a specific aim of design fiction however, there are already examples of design fiction being used and applied to commercial projects (Thales Group, 2021).

Though there are an ever-increasing number of examples of design fiction, there are three key approaches to future visioning projects that are the primary influences for this research. These are the work of the design collective Near Future Laboratory, in particular their 'Ikea Catalogue from the near future' (Bleecker, 2015); Strange Telemetry, which was a design research consultancy, in particular their 'Future of an Ageing Population' project (Voss *et al.*, 2015a); and the work of speculative design researcher Paul Coulton, particularly his research on 'Design Fiction as World Building' (Coulton *et al.*, 2017). Each of these works are discussed in greater detail over the course of

[2] Both Speculative Design and Design Fiction are introduced and explored in greater detail in Chapter 2 Part 3. They are introduced here to explain how they relate to established and emergent futures research.

this thesis and have been influential because they provide an alternative approach for how we, as designers, create and present visions for the future.

Near Future Laboratory's 'Ikea Catalogue from the near future' (Bleecker, 2015) [Fig. 1.4] was the result of a workshop intended to encourage conversations around the future of connected devices, collectively referred to as the Internet of Things. They used design fiction as a "way of digging into the details, discussing the known topics and raising many more unknown ones"(Near Future Laboratory, 2015). The format of an Ikea catalogue was chosen as a suitable design for the resultant artefact, as it is easily recognisable in many parts of the world and represents normal, ordinary and everyday life. The design fiction Ikea catalogue offers a way to begin talking about near futures, the ideas portrayed within are not aspirations, expectations, or predictions, but are intended to encourage a discourse around the kinds of futures that we (as a society) would prefer. Other examples of this approach by the Near Future Laboratory have resulted in design fiction Quick Start Guides, Newspaper Supplements, and Reports, offering relatable ways to enter discussions around futures (Near Future Laboratory, 2021).

Figure 1.5 Ikea Catalogue from the near future, Near Future Laboratory, 2015 - The IKEA catalogue was chosen as a suitable format for a Design Fiction artefact as it offers a compelling way to represent everyday life that is recognisable to many parts of the world[3].

The Strange Telemetry project, the *Future of an Ageing Population* (Voss *et al.*, 2015a) [Fig. 1.5], used techniques drawn from speculative and critical design, and saw the first use of speculative design in UK government policy processes. Whereas the Near Future Laboratory's Ikea catalogue was created as a result of public workshops, Strange Telemetry produced their visual artefacts as tools to guide discussions and debate during public workshops, running a series of 3-hour workshops, in which the visual artefacts were deployed as a tool to elicit specific and sufficiently granular responses to the uneven ways in which an ageing population could impact on employment, mobility, and the provision of key services. The visual artefacts took the form of digital mock-ups of

[3] Julian Bleecker (2015) explained that the catalogue format was chosen "for its compelling ways to represent normal, ordinary, everyday life in many parts of the world." Much like all design fictions, the aim of this artefact "is to encourage conversations about the kinds of near futures we'd prefer, even if that requires us to represent near futures we fear."

possible future workplaces and urban transit systems, with specific changes made to each of the scenario sets, to make them site specific. This was done to make the future visions more relatable to the public audience. The project presented Strange Telemetry with the opportunity to begin the design and production of tools for bridging speculative design, policy and strategic foresight, alongside the facilitation of "public engagement with the complex, messy realities of socio-technical systems" (Strange Telemetry, 2017: para.10). Importantly, this project was also an early example of speculative design work being done outside of the confines of a gallery or exhibition space, engaging directly with the public that it was intended for. The successes and failures of this project are discussed in greater detail at various points throughout this thesis.

Figure 1.6 Future of an Ageing population project, Strange Telemetry, 2015 – Strange Telemetry's described their artefacts as digitally-rendered speculative image, depicting possible aspects of work, services, or transport provision in the year 2040, and tailored to the city that each workshop was held in. Though the realism for these scenarios was generated through a literature review and only a surface level foresight analysis of the subject for each workshop (Voss et al.*, 2015b).*

There are numerous examples of *design fiction*, the work of Coulton et al. (2017) however, is of particular interest to this research as it explores the potentials of *design fiction* for *world building*. In the context of this research, this is the creation of future visions with the intention to showcase or prototype technological concepts. *World building* is a powerful approach, as it allows the creator to introduce new systems, alternative political realities and provides a window into what it would mean to live within that reality and even offering a possibility of how to challenge the status quo (Zaidi, 2019). However, further work is required to develop design fiction methods that live up to the promise of successful engagement with the public (Voss *et al.*, 2015b).

In efforts to tackle this criticism, rather than creating physical diegetic prototypes (artefacts) as the focus of the work, *design fiction as world building* instead appropriates widely familiar formats, some of which are more commonly associated with technology companies, such as promotional material, product videos, device documentation and manuals, such as those shown in figure 1.7 below, which are used to create plausibility (Coulton, 2020; Gonzatto *et al.*, 2013). This is necessary as there needs to exist a bridge between "the audience's perception of their world and the fictional element of the concept" (Auger, 2013: p.2).

Within these design fictions the objects and artefacts produced are diverse and varied, but the end point is always the creation of a fictional world. Within a single *design fiction*, the specific media and forms used should be considered as a collection of standalone artefacts, which together build the world [Fig. 1.6]. Each of these artefacts, that contribute to making up this *design fiction*, is a metaphorical entry point into the fictional world, with each artefact being a representation of that world, at differing scales, providing the backdrop for human experiences as well as the mundane and everyday lives (Zaidi, 2019). *Design fictions* on the other hand "implicitly have an elucidative edge. Being exploratory and inquisitive is a definitional characteristic" (Coulton et al., 2017: p.6). The artificially built world is therefore a prototyping platform for the very designs that define it, and in turn these designs prototype the world.

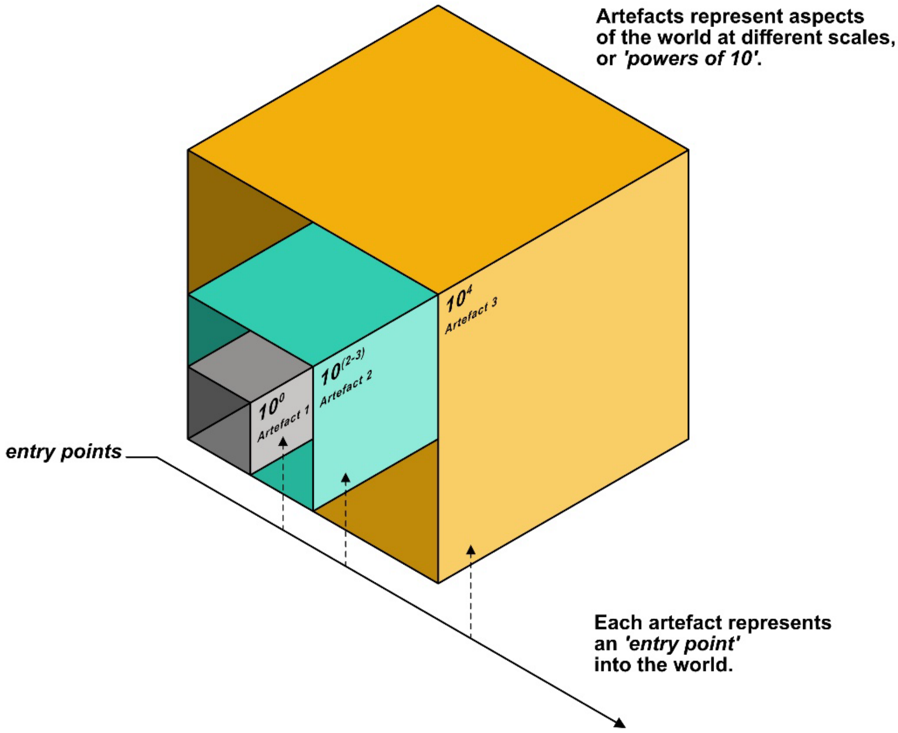


Figure 1.7 Design Fiction as World Building, Paul Coulton et al., 2017 (redrawn by author) – This diagram was inspired by the Powers of Ten short film by Charles and Ray Eames (1977) *and considers the artefacts that build design fiction worlds to represent views of those worlds from a range of scales, whilst also acting as 'entry points' to the world (Coulton* et al., *2017).*

1.5 Research Aims

The research aim is to develop a methodology for the creation of *graphic social futures*, which are themselves socially constructed. Social Construction is itself a sociological theory, which Crotty (1998, p.42) described as "the view that all… knowledge, and therefore all meaningful reality as such, is contingent upon human practices", with Burr (2015, p.3) explaining that social construction requires us to be "ever suspicious of our assumptions about how the world appears to be". Taking inspiration from this, in the context of this research, socially constructed futures are defined as futures which are informed and influenced by the expectations and anticipations of the public who engage with this research, as opposed to representing the core values and beliefs of large corporations or wealthy and powerful individuals, or those of the designer. This research uses the lens of social futures as distinct from technological futures, to explore alternative pathways in relation to the future of 3D printing. Whilst economics and technology are clearly important, social futures research takes the stance that it is necessary to attend to a wider range of social considerations that are vital for humanity, other species and the planet to flourish. Social futures "reveals a shift to the embodied and embedded ways that humans anticipate, imagine and live futures in their messy, socially imbricated lives" and "a shift in gaze to matters of difference, to specific times, places and people, from which intersections futures emerge. This is futures thinking as localized and lived, not putatively generalized (indeed, generalizable) and abstract" (Lopez-Galviz and Spiers, 2021: p.1).

This research tests different methods for engaging with people concerning what and how they think about futures for 3D printing, specifically how this could affect their future lives. The technological device is here used as a driver for change, it provides a catalyst around which the research participants can imagine an alternative future but is not the focus of the research.

1.5.1 Research Objectives

To achieve this, there are two primary research objectives:

> **RO1:** To develop a methodology for the creation of graphic social futures; visions for which are informed by the data gathered through research workshops that engage with the public.
>
> **RO2:** To develop processes for encouraging and guiding public engagement in futures thinking.

1.5.2 Research Questions

These research objectives will be achieved by answering two primary research questions:

> **RQ1:** How can we better engage with, and subsequently guide the public in futures thinking?
>
> **RQ2:** What are the necessary stages for creating speculative visions, that are informed by the expectations and anticipations of the public, to advance these conversations concerning futures?

RQ3: What are the strengths and weaknesses of this approach to the creation of graphic social imaginaries?

1.5.3 Research Problem

There are well established techniques for thinking about the future, many of which are founded on the work of Slaughter, predominantly his four-stage methodological approach (2002b) as shown in figure 1.8. It is the final of these four stages, *iterative and exploratory methods*, that this research is primarily concerned with, as this is the method that involves scenarios and visioning. However, each of these stages is addressed by this research, with the specific methods explained further at the point of relevancy to the discussion. These methods enable the creation of future images, or visions, which are used by futurists to not only forecast but also to encourage potential futures (Dunn and Cureton, 2020b). Through the creation of alternative futures, visioning allows us to explore different options and as a society negotiate our values and preferences. It has even been argued by Polak (1973) that societies shape themselves partly through the images of the future that they construct. However, despite the numerous tools and techniques available to aid in the consideration and creation of visions, futures continue to be dominated by technological aspirations and determinism (Urry, 2016).

Input Methods	Constructing near future context Delphi Environmental Scanning
Analytic Methods	Cross-impact Forecasting and trend analysis Backcasting
Paradigmatic Methods	Layered causal analysis Critical futures studies Systems thinking
Iterative and Exploratory Methods	Scenarios Visioning Futurescan

Figure 1.8 A dozen futures methodologies grouped under four headings as described by Slaughter (2002b).

It has been noted that the creation of visions and visioning has become entangled with commercial and business strategy, and therefore promotes the core values and beliefs of corporations (Meadows and Kouw, 2017; Coulton and Lindley, 2017), rather than representing the aspirations of a society. This can be problematic as designers have to proceed in terms of their own understanding of the world, and their ideas have been shaped by their own individual experiences, design education, and demographic positioning. What 'makes sense' to the designer will most likely be in accord with the designers' tacit assumptions. To this end, Whiteley (1993) instead proposes that public concerns about design outcomes might appropriately be taken up in a public way, rather than the responsibility laying solely at the feet of designers.

This then raises the question "how might design move into public debate, systematic inquiry, and institutional practices in unprecedented ways?" (Woodhouse and Patton, 2004: p.3). Despite this question being raised at the beginning of the 21st Century, there remain calls for "futures to be seen, heard and performed through the social" (Lopez-Galviz and Spiers, 2021: p.15). As previously explained, *design fiction* offers a way of exploring alternative futures, which can be free from commercial influences or constraints, which offers a growing number of examples of *co-designed design fictions* (Ullstein and Hohendanner, 2020; Qualified Selves, 2019; Ullstein and Mizuno, 2021). However, this research argues that these examples are still not representative of 'design by society' or socially designed, being that they are influenced and informed by focus groups, comprised of those who are "deemed to have 'expertise' – scientists and technologists, political scientists, economists, but rarely wider publics" (Voss et al., 2015b: p.3). There are examples of social futures research that use illustrations to encourage discourse around futures thinking, such as the ReOPen CiC project shown in figure 1.9, which proved to be successful in helping and encouraging workshop participants to consider and discuss the future. Whilst these illustrations were inspired by the reflections and responses from participants in previous community workshops, each illustration represented only a singular past event or experience. It is the view of this research that approaches to visualisations such as this do not result in scenarios which are easy to engage with at a level deeper than that of an observer. That is to say that whilst they are successfully presenting a scenario, they are very limiting in terms of entry points into the speculative world, and as a viewer you are presented with little opportunity to add to, or create your own narrative for the scene, due to the pre-established narrative embedded within the scenario.

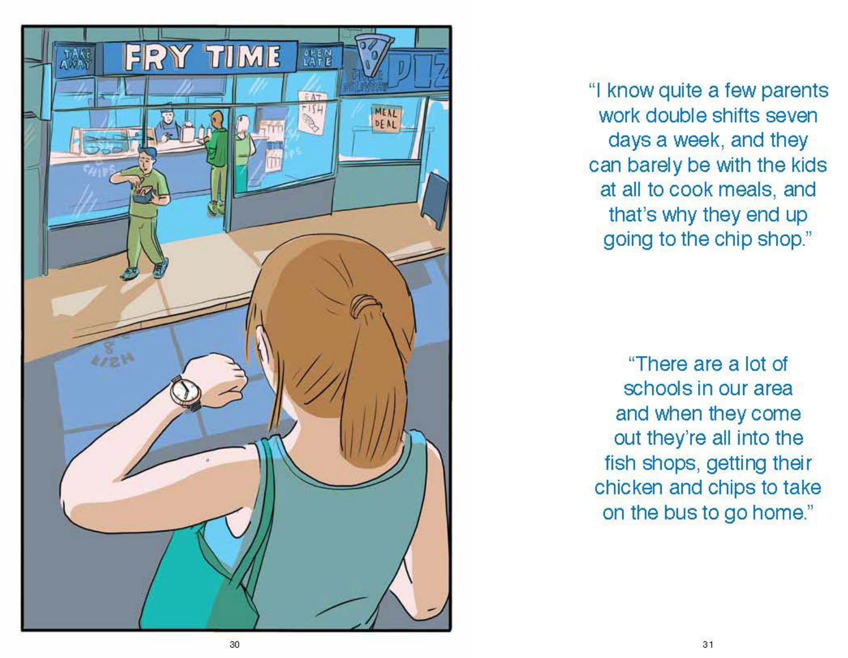


Figure 1.9 ReOPeN, CiC's [Communites in Control project], Joe Decie et al., 2018 *– An example of graphic futures, a graphic narrative "Communities in Control" about health inequalities in England. The graphic narrative booklet presents communities' stories, and contains illustrations inspired by reflections from residents and community workers who attended a workshop on health inequalities.*

Therefore, further work is needed in addressing the issue of how to better engage with the very public that this method is purported to be concerned with, and how to use the results of these engagements in a more meaningful way. Visioning is a useful tool and is commonly understood as a means of presenting futures as it is highly accessible and effective for engaging with publics (Ding and Ames, 2005).

Futures visioning is well established as a means of exhibiting and representing the core values and beliefs of corporations, as at a macro level they convey "an organisations view of the future" (Li et al., 2014: p.87), though as Curry (2021: p.31) points out, there is a question about an organisations willingness to "reflect self-critically on the nature of the systems it enacts". It was therefore considered by some, that futures scenarios were underexplored as a process for representing the values of society (Ackoff, 1993; Slaughter, 1989; Mochelle, 1986). Despite the innovation and excitement surrounding futures scenarios at the close of the 20th Century, the turn of the century saw the decline of scenarios as a method, with innovation focusing elsewhere (Curry, 2021). However, with renewed calls for futures to be social (Lopez-Galviz and Spiers, 2021), and an increasing focus on scenarios (Li et al., 2014; Milestad et al., 2014; Soria-Lara et al., 2021; Fuller, 2017; Sheppard et al., 2011), this research considers them to be an appropriate method for "interrogating and better understanding the future" (Lopez-Galviz and Spiers, 2021: p.3).

However, the development of a reliable process for the creation of social led scenarios is problematic as the social imaginary is a highly complex thing, comprised of many layers and cultures (Gilleard, 2018), which can be extremely challenging to represent. Sufficient understanding of these complex relationships is necessary to successfully create graphic representations of social futures, and there needs to be an understanding of what underpins the social structures in existing visions of the future. On this matter, Slaughter stated: "I do not believe it possible to approach the great issues of our time without considering the frameworks of meaning and value which created them in the first place" (Slaughter, 1989: p.454). Therefore, if we are to truly understand the major problems that futures research can explore, it is also necessary to understand the root causes of these problems. This idea had previously been demonstrated by Richard Mochelle's (1986) architectural metaphor which relates surface structures to underlying foundations [Fig. 1.10]. Mochelle drew a parallel between physical architecture and social architecture. The superstructure comprises familiar components such as buildings, streets and signs, supported by the underlying framework, then foundations and the site upon which the whole complex sits. Similarly, the social structure, such as language and symbols, customs and laws etc. rest on the hidden underlying structure of cultural norms, assumptions, ethical and moral commitments, which themselves stand or fall on the epistemological foundations of a worldview or paradigm. Slaughter (1989) considered this a clear demonstration why superficial analyses often fail: they only consider the surface structures.

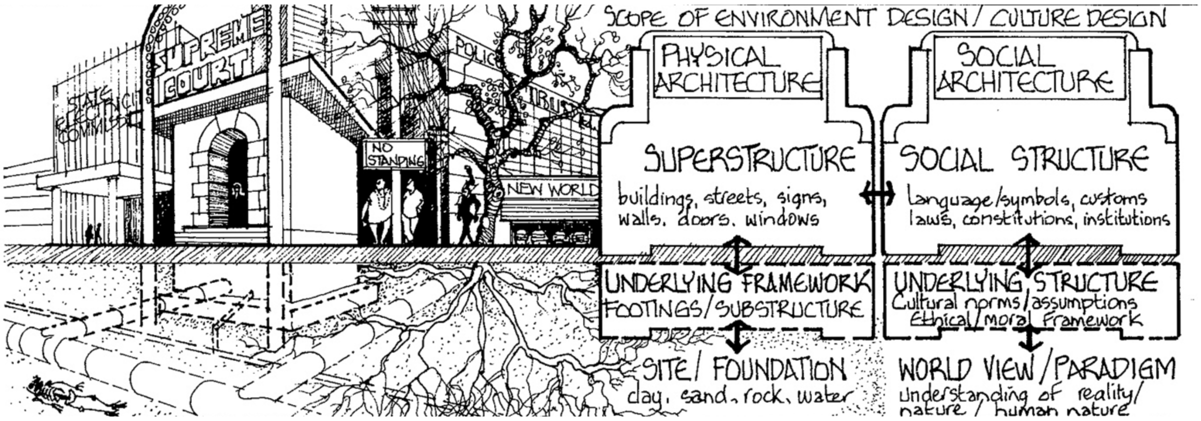


Figure 1.10 Architectural metaphor for relating surface structures to underlying foundations, Copyright Richard Mochelle, Integrative Services, Melbourne, Australia, 1986.

The creation of specific tools to help engage the public in futures research, to help guide discussions, and to reveal the existing underlying social structures is important, because "being 'futures literate' enables people, together, to appreciate the world more fully, to use the future to innovate the present" and furthermore, it is "the futures we imagine, which drive our expectations, disappointments and willingness to invest or to change" (Miller, quoted by Spiers, 2021: p.39).

1.6 Research Significance

The futurist Roy Amara's (1981) third "Law" of futures states that future outcomes can be influenced by our choices in the present, whilst the future cannot be predicted, alternative futures can be explored, and preferred futures can be imagined. It is therefore important that we have the tools to create visions that represent preferable and social futures, to provide society with something to aspire toward. As Frisch (1998) argued however, workable and preferable futures do not just happen, they are highly dependent on the process of vision development itself. Furthermore, he argues that for visions to be successful, they must appeal to people, and inspire them to work towards the realisation of the vision, and for this to happen, the visions must be widely understood and embraced. A key factor in this is the involvement and participation of relevant stakeholders in the process, as this helps to ensure enthusiasm and active support for the visions which emerge (Ackoff, 1993). Dunn and Cureton (2020b) have pointed out that by presenting multiple futures, visioning affords us the ability to discover and explore different options. Furthermore, these visualisations have the potential to play a critical role in allowing those who are exploring potential futures to capture and share their ideas. This is particularly important as many social services and solutions to social problems exist now only because they were fought for and achieved by concerted action, something which is only possible once a solution has been identified.

This leads us to the thorny issue of agency and the degree to which people understand their capacity for action. Spiers (2021: p.38) states that "for an action or inaction to be agentic, it must align with an individual's values, and this successful alignment, along with the unconstrained potential to undertake said action or inaction, remains key to an individual's sense of wellbeing." Spiers goes on to further explain that it is here that we begin to see links between agency and futures literacy, another cornerstone of social futures research, which is framed as 'capability'. Futures literacy is important as it enables people to "appreciate the world more fully, to use the future to innovate the present" (Miller, quoted by Spiers, 2021: p.38).

This research takes the view that every participant is themselves an expert in considering their own social future, and therefore seeks to use these individuals' stories to reveal these otherwise unnoticed aspects of social reality. These 'stories' are used to inform the creation of alternative social imaginaries, future visions which are socially constructed, in contrast to the pervasive commercially driven future visions. These graphic social futures are intended as a tool to encourage discussion, explore potential futures and negotiate our values for a *preferable social future*.

1.7 Structural Outline

This thesis is composed of eleven chapters as shown in Figure 1.11 which is an outline map of this thesis that will now be described.

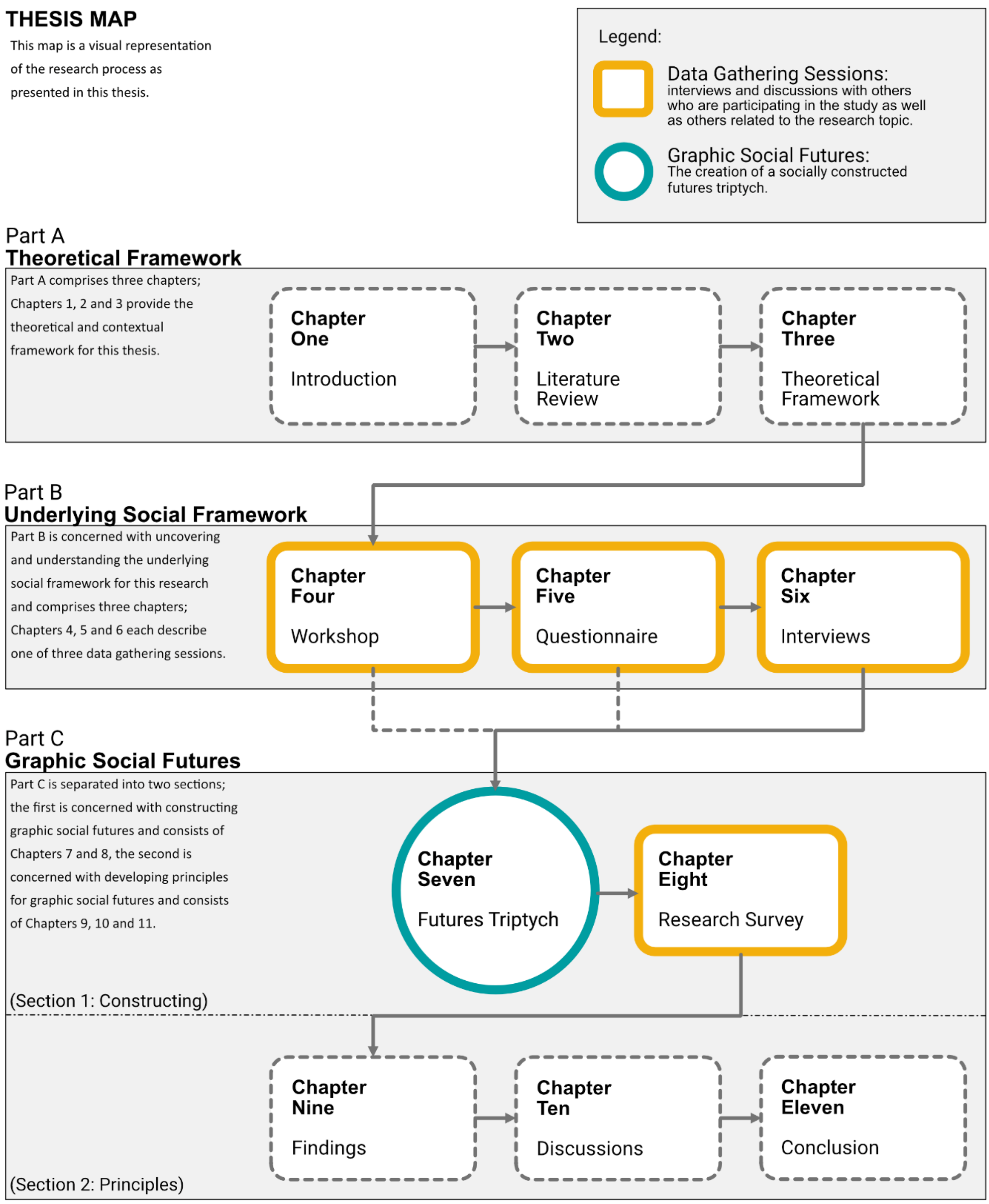


Figure 1.11 Visual Thesis Map – This diagram provides a visual representation of this thesis, indicating the three distinct parts and the chapters that comprise them.

Chapter One introduces the context of this study along with the research objectives and questions, and an argument for the value of this research is then made. Chapter Two presents the relevant existing literature in two parts, the first of which discusses the existing influences on the social imaginary concerning 3D printing technology. The second is concerned with introducing and explaining several approaches to futures research which can contribute to the creation of socially constructed imaginaries. In Chapter Three, the theoretical framework for the study is presented. The adoption of a variety of theories and approaches is explained and justified, and the broader research design is discussed, including the limitations thereof.

Chapter Four presents the first of four data gathering sessions, describing the aims and scope of this data gathering session, followed by an explanation of the methodology and the process undertaken in designing this research activity, and subsequently the process of data analysis is discussed. Chapter Five and Six present the second and third data gathering sessions respectively. The aims and scope of these data gathering sessions are described, followed by an explanation of the process undertaken in designing these research activities, how it was informed by the experiences of the previous data gathering sessions, and the subsequent careful analysis of the gathered data.

Chapter Seven describes the creation of three future visions, explaining how the graphic social futures triptych has been informed by the findings gathered throughout the data gathering sessions. This is followed by Chapter Eight, which presents the fourth and final data gathering session. Firstly, the aims and scope of this data gathering session are described, followed by an explanation of the process for using the graphic social futures as a research tool. This is followed by an explanation of the careful analysis of the gathered data that resulted from this data gathering session. Chapter Nine then discusses and examines a series of interviews that took place, concerning the graphic social futures, to evaluate the efficacy of this research methodology to explore and envision alternative imaginaries for social futures.

Chapter Ten presents a discussion on the successes, limitations and challenges of the methodology that has been developed through this research. This is achieved by evaluating the effectiveness of using socially constructed illustrations and accompanying questions as a research probe. Chapter

Eleven then concludes this thesis by presenting principles for the creation of graphic social futures will be presented, alongside a conclusion to the findings of this research.

From a structural and thematic point of view these chapters are grouped into three parts, which can be understood as follows:

1.7.1 Part A: Contextual and Theoretical Framework

Part A comprises three chapters, Chapters One, Two and Three which provide the theoretical and contextual framework for this thesis. Chapters One and Two introduce the futures field of study that this research sits within, with particular attention being paid to futures scenarios and visioning, and the relatively new field of Social Futures and positions it within the wider field of futures studies. A review of contemporary examples of “pop” futures that speculate on the future of 3D printing is then discussed, which serves to explain the role that future visions can play in influencing the social imaginary. This is followed by an introduction to the maker movement, a grassroots global collective of early adopters of personal digital fabrication equipment, providing a grounded alternative to the “pop” futures as promoted by the media. Chapter Two then concludes with the introduction of several alternative approaches to future visions, not restricted or influenced by commercial interests. Chapter Three presents the varied research theories and approaches that have been adopted to explore futures visioning as described in Chapters One and Two.

1.7.2 Part B: Underlying Social Framework

Part B is concerned with uncovering and understanding the underlying social framework for this research and comprises three chapters. Chapters Four, Five and Six, each explain the relevant methodologies that are being used and describe in detail the design of, and findings, from three information gathering experiments which are referred to as data gathering sessions. The efficacy of, and findings from each of the data gathering sessions are described in detail before being carefully analysed. These are then used to inform the subsequent data gathering session, which is the subject of the following chapter. Each of these data gathering sessions contributes to an understanding of the underlying social framework, which is necessary to establish the foundations for the development of the graphic social futures. This careful and detailed process of wide information gathering, and careful analysis is necessary to pave the way for deeper interpretations, and offers the potential for creating more robust forward views, as described in Part C.

1.7.3 Part C: Graphic Social Futures

Part C is separated into two sections; the first is concerned with constructing graphic social futures and consists of Chapters Seven and Eight, the second is concerned with developing principles for graphic social futures and consists of Chapters Nine, Ten and Eleven. Chapter Seven describes the process of how the findings from each of the data gathering sessions and their critical interpretation has been used to inform a triptych (artwork made up of three pieces) of future visions, which are examples of graphic social futures, future visions that are themselves socially constructed. Chapter Eight then describes the process of designing and running an online research survey, using the graphic social futures triptych as a platform for provoking reactions and responses. The results collected from this research survey are then carefully analysed and discussed.

Section two of Part C begins with Chapter Nine, which presents the findings from a series of interviews, carried out to reveal and understand how the graphic social futures had performed as a platform for discussion. Chapter Ten then follows with a review and discussion on the processes and challenges of this research and provides guiding principles for the design of graphic social futures. Finally, Chapter Eleven concludes the thesis by reflecting on the findings from the data gathering sessions, research survey and interviews, provides detailed answers to the research questions, acknowledging the limitations of this approach, and suggests directions for future research in this field.

2.0 Literature Review

2.1 Outline

This research uses a design lens to explore futures thinking and visioning that relates to social futures. To achieve this, it uses an investigation into the perceived potential futures of digital fabrication technologies as a vehicle to engage the public in futures research. This literature review is therefore presented in three parts, which together describe the contextual framework for this research.

Part One begins with an introduction to 3D Printing, a technology which emerged onto the consumer market over a decade ago, accompanied by a great deal of excitement and optimism. Whilst the rate of adoption for 3D Printing has steadily risen (Roberts, 2021), the opening section of this chapter will show that the impact of this technology in the domestic setting has (to date) not lived up to the hype which surrounds it. This hyperbole is then contrasted with the reality of 3D printing technology and the social group of users who have played a major role in the support and development of consumer 3D printing, the *maker movement* (Fassio and Grilli, 2015). This group have had a direct impact on the emergence of this technology, providing a large sample of early adopters and acting as something of a social incubator space (Dopplick, 2015). Understanding these early adopters and their existing use cases for this technology can provide insights into how 3D printing could potentially establish its place within our everyday lives. This then leads to the introduction of *open-source design* and *open-source manufacturing*, a new means for the design and production of software, hardware and goods. This, alongside the maker movement, provides the context for the emergence of 3D printing technology, one that combines the technological with the sociological. This is important for understanding the new ways in which people are sharing skills, techniques and methods for using these devices, which has a direct impact on the public's understanding of the *innovation* itself (Rogers, 2003). The process by which a technology is successfully adopted and diffused into society is a complex one (Rogers, 2003; Straub, 2009). However, a major factor for both adoption and diffusion of technology is *Awareness* and *Communication Channels*, which is known to be highly influential in this decision process and can itself be influenced by the way in which a technology is marketed and presented by the media (Heiman *et al.*, 2020). Therefore, an examination of existing and current representations of 3D printing technology is carried out, to reveal the increasing delamination between the expectations and anticipations of this technology, and its real-world capabilities[4]. This sample of material is important for describing the current influences on the social imaginaries for 3D printing. This is especially true for technologies which do not belong to an existing market (such as 3D Printing), as these depictions of the technology can in some instances provide the only influence or reference that some people have for this technology (Nelkin, 1987).

Part Two begins with an introduction to the relatively new field of futures research, social futures. Social futures research strives to move away from futures that are presented and discussed as deterministic extrapolations of technology or present events, instead taking an informed and imaginative look at likely future scenarios and asking how we may, could or should proceed. Social futures research is entangled with ideas about technology, society, the environment etc., as social futures research takes the stance that futures in the Anthropocene are social because they are shaped by the accretions, excretions and exhalations of the social (Büscher, 2018). Social futures therefore aim to give a voice to past, present and future societies, including those who are often left out of these discussions. This is discussed in connection with *social design*, a design approach that suggests "public concerns about design outcomes might appropriately be taken up in a public way" (Woodhouse and Patton, 2004: p.3), which seems an appropriate approach for developing socially constructed imaginaries.

Another important element of this approach to visioning, is the consideration and inclusion of the past as an influence on the future present. Approaches such as *the future mundane*, seek to present

[4] It is worth noting at this stage that a major part of the 3D printing process is the production or acquiring of a suitable virtual 3D model for the object or artefacts that are to be printed. Whilst this can be problematic for some users and raises potential issues concerning intellectual property and copyright etc. this is outside of the scope if this research as this aspect of the process is for the most part not discussed in the mainstream marketing and media representation of this technology.

a future that is more representative of the social and the real, as “accretive spaces, where contemporary design and technology sits side by side with older artifacts” (Foster, 2013: para.11). The final section of this literature review introduces design fiction as an alternative to fictions constructed and driven by hype and corporate visions. The means of creating strategic foresight, aptly named future visioning (Slaughter, 2002b) is an established and well recognised method, which has been used for speculating on the future of technology. However, in a similar manner to the narratives as presented in the mass media, future visions can also succumb to their own hyperbole. This is discussed in the introduction of *design fiction as world building*. Speculative worlds created in this manner avoid predicting futures and instead explore alternative scenarios, as “although the future cannot be predicted, we can help set in place today factors that will increase the probability of more desirable futures happening” (Dunne and Raby, 2013: p.6). One of the aims of design fiction is to be free from commercial constraints, and as such is not concerned with promoting or predicting futures, but is instead concerned with highlighting the possible, and envisioning the possibilities that could, and perhaps more importantly, should manifest.

2.2 Part 1: Context

2.2.1 3D Printing, an Unrealised Utopia

Over the past two decades additive manufacturing, colloquially referred to as 3D Printing, has received a great deal of attention for its potential impact on society. This technology is accompanied by a great deal of optimism and hype, with headlines such as “This Machine Will Change the World” (Anderson, 2012)[Fig. 2.1], “3-D Printing Will Change the World” (D’Aveni, 2013) and “3D Printing Is About To Change The World Forever” (Smith, 2017). It is difficult to think of an industry that could not be potentially affected by additive manufacturing, with research ranging from the printing of programmable digital materials (Hiller and Lipson, 2009) to the direct 3D cell-printing of human skin (Kim *et al.*, 2017).

Figure 2.1 WIRED The Design Issue, October 2012 – An example of the bold claims made regarding consumer grade 3D printing technology.

Whilst this technology has been available since the mid-1980s, the consumer market for 3D printers rapidly expanded in the 2010s following the expiration of 20th Century patents[5] (Sargent and Schwartz, 2020). There has been an increasing level of investment in the research and development of 3D printers, which has seen the price of consumer models fall. 3D Printers in the low hundred-

[5] The first forms of what we now colloquially refer to as 3D printing were invented in the early 1980's. In the period between 2002 and 2014, around 225 early 3D printing patents expired. In 2004 the RepRap project was founded; it was an open-source project which aimed to build a 3D printer that could print most of its own parts. The idea behind it was to democratize 3D printing by making the technology available to people around the world. This created an entirely new space in the manufacturing industry, which today is dominated by companies such as *Prusa Research*, *BCN3D*, *Ultimaker* and *Creality* which are each to some extent built upon the open-source RepRap platform. (Hornick, 2016; Ultimaker, 2023; E3D, 2020).

pound range can now be used directly out of the box or following some simple assembly. According to *Wohlers 2019* report on additive manufacturing, 591,079 consumer 3D printers were sold globally in 2018, and in total, 2 million consumer 3D printers have been sold worldwide from 2015-Present [Fig. 2.2]. Though this is likely to be an underestimation as this figure does not include those consumer printers which are assembled from parts or those purchased as a kit (ibid.). However, it is now nearly a decade since the bold claims for 3D printing were first made, and we are yet to see the widespread impacts to our everyday lives that this technology was predicted to have.

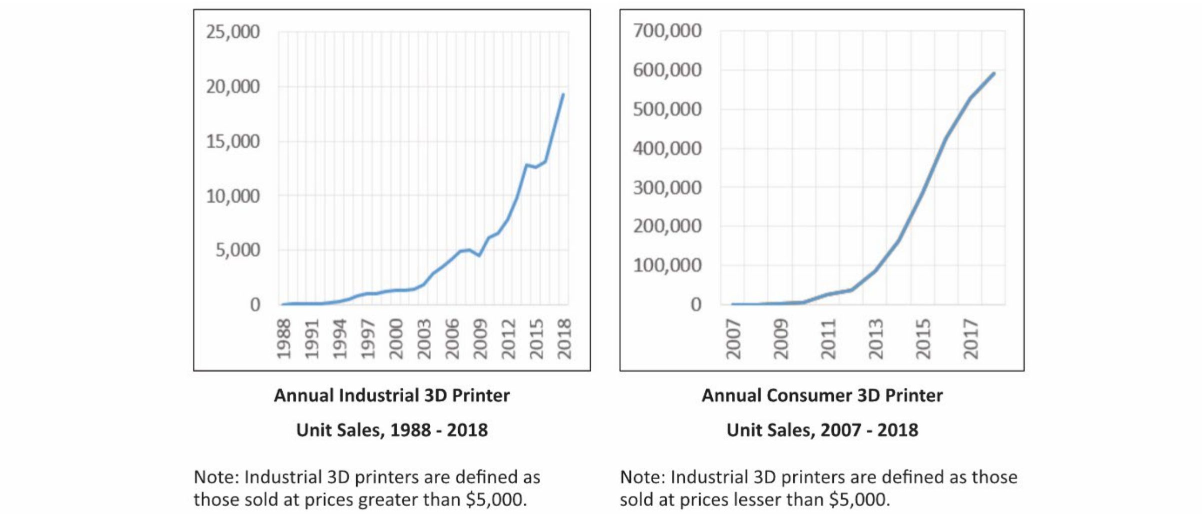


Figure 2.2 The Wohlers Report for Additive Manufacturing, 2019 – The report estimates that annual 3D printing industry revenues reached $9.975 billion globally in 2018. On average, 3D printing industry revenues have grown annually over the past 30 years by 26.9%, and it is estimated that over two million consumer 3D printers have now been sold worldwide.

Whilst consumer 3D printing has not yet permeated into our everyday lives, the technology has been widely adopted by a group of users who are referred to as '*makers*'. The *maker movement* and the act of *making* is often discussed in utopian terms (Ehn *et al.*, 2014; Walter-Herrmann and Büching, 2013), with advocates of *making*, such as Hatch (2013), talking of empowerment by the tools of production and the potential for broad social, economic and political impacts. However, this utopian rhetoric could be considered examples of what Wright described as "fantasies, morally inspired designs for the humane world of peace and harmony unconstrained by realistic considerations of human psychology and social feasibility" (Wright, 2015: p.4). It is also worth noting that despite this utopian rhetoric of social empowerment and the democratisation of technology (Kerschner *et al.*, 2018; Tanenbaum *et al.*, 2013; Menichinelli and Molina, 2018; Bean and Rosner, 2014; Shea, 2016; Bosqué, 2015; Bakhshi *et al.*, 2013), the rapid rise of the maker movement has been in part enabled by financial support by corporations such as, Autodesk, Intel, Microsoft, Qualcomm and Makerbot, Arduino and Ultimaker; which all have a vested interest in selling hardware (Lindtner *et al.*, 2016). It is unsurprising then that the marketing material and hype surrounding this technology amplifies this utopian rhetoric.

2.2.2 Barriers and Challenges

Despite the hope and optimism surrounding 3D printing there is a growing awareness of the challenges faced by this technology in achieving its potential (Smith and Maier, 2017). A major complication for 3D printing is that it does not fit into an existing market, as reflected in the various ways 3D printing is both advertised and reported which are highly inconsistent. In some instances, it is a device that can produce anything 'limited only by your imagination' (WSJ, 2013), in others it is a professional tool for small scale manufacturing. Whilst the relationship between the Maker Movement and 3D Printing would appear to be a symbiotic one, in some ways it is also a detrimental one. On the one hand it has provided a fantastic platform for those who are early adopters to engage with this technology, which in turn has contributed to the hype and media attention 3D Printing has received. But on the other hand, for those individuals or groups who do not identify as *makers*, the association with the maker movement is sometimes viewed as a barrier (Toombs *et al.*, 2015).

Whilst researching the political imaginaries of 3D printing, design researcher Jesse Stein defined three distinct imaginaries (2017), these were:

1. Maker-as-entrepreneur: 3D printing as an enabler for the individual maker as a neoliberal entrepreneur in a world of capitalist opportunity.

2. Economic revival of the nation state: 3D printing as a boon to productivity through the "onshoring" of manufacturing, enabling national economic revival, particularly in the Global North.

3. Commons-based Utopia: 3D printing as a social tool in a post-capitalist, commons-based Utopia featuring material abundance, shared resources, and widespread community control over the means of production.[6]

Despite the conflicting political alignments of these visions, it was noted that they did share one important theme: a growing public awareness of design and production. However, this poses another barrier to 3D printing, considering that designing three dimensional models can be a complex task, sometimes requiring specialist software and a high level of skill. An increased awareness of design and production does not necessarily mean there is an increasing level of skill or ability that would allow an increasing number of individuals to perform these tasks.

2.2.3 The Maker Movement

Considering the multitude of fictional depictions for 3D printing[7], it could be argued that for the majority of people who have not yet engaged with this technology, the notion of 3D printing still inhabits the worlds of science fiction. There exists, however, a group of users who have already embraced this technology and for the past decade have been experimenting with how they can exploit it for real world applications. When discussing the emergence of consumer 3D printing, it is hard to avoid mention of this social movement that it has become intrinsically linked with, the *maker movement*. The *maker movement* has developed alongside the rise of 3D Printing and has helped to create a suitable social environment for the technology to establish itself. The process of technology adoption can be altered through social interactions (Bijker and Law, 1992), and this social element is

[6] It is important to note that Stein does acknowledge that not all writing about 3D printing features exaggerated or utopian themes and there are other political imaginaries that do not fit neatly within these three categories. The visions described are highlighted because they repeatedly emerged as key themes in their analysis of 3D printing literature.

[7] Examples of these depictions will be shown and discussed later in the chapter, in section 2.3.2

very much at the heart the maker movement, a global sub-culture representing a technology-based extension of DIY culture. While technology may have been the spark that kick started the *maker movement*, it has since developed into a social movement for all kinds of making and makers (Dougherty, 2013).

These groups have emerged alongside the creation of *FabLabs* and *Makerspaces*, the aim of which is to enable open innovation, knowledge sharing, and peer-to-peer learning (Capdevila, 2013), by providing anybody with “access to the modern means to make things” (Gershenfeld, 2012: p.48). Whilst research has shown that the technological innovation and production processes that have been created through the use of these spaces is often limited (Troxler, 2010), it has also been noted that the two main achievements of these labs (as defined by Fab Lab managers and assistants) are community bonds and individual empowerment (Wang *et al.*, 2015a). At the core of the maker movement are the ideals of equity and access for all, which very much resonates with the ideals of social futures, as these are key elements required for their formation.

The Horizon 2020 *Make-It* project (Menichinelli and Molina, 2018) recognised that the maker movement is not a fixed entity, but is instead a rapidly expanding field, constantly in flux. Their approach to defining the maker movement was to focus on the overlap between what they deemed to be the four main strands and fields of activity [Fig. 2.3]. *Digital fabrication* is the first strand as it provides the technological underpinning of the maker movement, by unifying design with production. The second strand is *Community Awareness Platform* as these are necessary for makers to exploit communication platforms for collaboration, sharing and learning purposes. The third strand is *Crafts and Do-it-Yourself*, which covers the process of manufacturing by hand with or without power tools. DIY in this context also represents ‘gateway opportunities’ for the unskilled or novice to create, modify or repair something without the direct aid of professionals. The fourth and final strand is *Creative Industries*, which share similarities and arise from craft and DIY cultures. Whilst being distinct from these, it is stated that makers are overlapping into these creative industries and providing “much of the new physical and digital inputs to these industries” (Menichinelli and Molina, 2018: p.37).

Figure 2.3 Adaptation of the maker movement diagram created by the MAKE-IT project Massimo Menichinelli and Maria Molina, 2018 (redrawn by author) – This diagram indicates the overlap between the four main strands and fields of activity that comprise the Maker Movement.

2.2.4 Origin Story

To understand the maker movement, it is necessary to first describe what is meant by the term maker, and the associated makerspaces from which this movement takes its name. It is also necessary to take into consideration a number of related movements, identities and spaces (Donohue and Marsh, 2019), an overview of which are shown in figure 2.4. There is already a great deal of research concerning the *maker movement*, and whilst there has been a great deal of effort focused on trying to understand and define the movement, this is a complex task (Prendeville *et al.*, 2016; Stewart and Tooze, 2018; Menichinelli and Molina, 2018). Whilst the maker movement is often referred to as a single body or organisation, it is in fact a collection of user groups, spaces and individuals who choose to identify with this movement.

Figure 2.4 Timeline indicating when some of the major companies, communities and organisations that contributed to the emergence of the maker movement were established.

When discussing the creation of *Make Magazine*, which is regarded as one of the founding moments for the maker movement, Dougherty (2013: p.1) explained that the origin of the movement lies in what he refers to as "experimental play". Dougherty recognised that makers were enthusiasts who played with technology to learn about it, new technology offered new opportunities. "Makers give it a try; they take things apart; and they try to do things that even the manufacturer did not think of doing". Others have described *makers* as the contemporary embodiment of the do-it-yourself ethos, engaging in creative projects and the practices of hacking (Alper, 2013; Knobel and Lankshear, 2001; Gauntlett, 2015). The term hacking was intended to connect technological enthusiasm with counter-cultural and rebellious tendencies (Morozov, 2014). It was first used in the 1950's by a student led Tech Model Railway Club at MIT (Donohue and Marsh, 2019), who stated;

> We at TMRC use the term "hacker" only in its original meaning, someone who applies ingenuity to create a clever result, called a "hack". The essence of a "hack" is that it is done quickly, and is usually inelegant. It accomplishes the desired goal without changing the design of the system it is embedded in. Despite often being at odds with the design of the larger system, a hack is generally quite clever and effective.
>
> (Tech Model Railway Club of MIT, Hackers, viewed 10 March 2021<http://tmrc.mit.edu/hackers-ref.html>)

It has been argued that the *maker movement* is the popularised version of the *hacker movement*, as they share many of the same principles and approaches to hands on learning, what Honey and Kanter (2013) would define 'design-make-play learning methodologies'. Both *making* and *hacking* involves the hands-on creation of material objects and so often requires the maker to have a combination of physical manufacturing and technical digital skills (Hughes, 2012; Kuznetsov and Paulos, 2010). The locations where these collective organisations meet are commonly referred to as *hackspaces* or *makerspaces*. Whilst many such spaces have arisen from grassroots networks, through a shared interest in developing a space for solo and collaborative work (Schrock, 2005), others are more formal organisations, such as *FabLabs* and *Techshops*.

2.2.5 Making Space

In much the same way that researchers have attempted to define the maker movement, efforts have also been made to define what makes a space a hackspace or a makerspace. Schrock offers a generalised description of how these two spaces differ;

> Compared with hacking, making is more involved with creating objects within a lineage of craft or art. Rather than hacking's strategic to bring about differences (an outcome),

> making is more concerned with an ongoing process and the satisfaction that comes from it. (2014: p.10)

Whilst far from definitive, this description does allow for the incredible variety of spaces that results from such loose organisational structures and range of participant identities. Another explanation is that over the years as the cost of digital fabrication tools, such as 3D printers, became more affordable, these *hackspaces* naturally evolved into makerspaces (Donohue and Marsh, 2019). Whilst there remain some conceptual and ideological differences between hackers and makers, in practice, these spaces (hackspaces and makerspaces) are in many instances indistinguishable, in terms of equipment and techniques. Hackers have expanded their interests into the fabrication of physical objects, and makers have also turned their attentions to the creation of software and programming (ibid.).

2.2.6 Maker Culture

In order to understand the role that the maker movement has played in the adoption of consumer 3D Printing, it is necessary to define the terms *hacker and maker* and differentiate between the different typologies of spaces that host these activities. However, whilst this helps to describe the context of the maker movement, it is perhaps much more important to understand the maker culture, as this relates directly to the social element of the movement, which is the factor that offers the most potential to impact the adoption of technology (Felt, 2017).

Whilst the skills and knowledge to *make* obviously play an important role, the maker culture, if it can be thought of as a single 'thing', is also an important part of making (Saunders and Kingsley, 2016). Alper (2013) defines the maker culture as a combination of behaviours, values and artefacts that are commonly shared amongst those who self-identify as makers. The global community of makers is comprised of groups of individuals who share this common interest in tinkering, hacking, re-making, and creating artefacts. These groups are often small informal collaborations, led by makers that “support and celebrate building and prototyping technical proof-of-concept exploration and ad-hoc product development” (Foster et al., 2014: p.24.4.3).

Donohue and Marsh (2019) describe the maker culture as one in which processes of creativity and innovation are key, others have traced links of its genealogy to that of craftsmanship (Schrock, 2014). Whether identifying as hackers or makers, the members of these spaces draw on “shared background of cultural references, values, and ideas” (Söderberg, 2013; p.1279) of a more popularised and accessible hacker culture, one which is specifically more social, every day and lived (Schrock, 2014).

Makers provide an opportunity to understand how a group of early adopters[8] for 3D printing see this technology fitting into their “daily routines and values of users and their environments” (Berker, 2006: p.2). The resultant artefacts that makers create often embody cultural imaginations, and so they are unknowingly engaging in the relatively recently articulated concept of design fiction (Dourish and Bell, 2008; Bleecker, 2009). The Steampunk movement is one example of this, a design fiction that re-imagines a world inspired by the Victorian era but technologically similar to modern times (Tanenbaum et al., 2013).

> The dominant paradigm of user-as-consumer gives way to alternative framings of the user as creative appropriator, hacker, tinkerer, artist, and even co-designer or co-engineer. These behaviours, taken as part of a broader movement, begin to form a politics of appropriation. (Tanenbaum et al., 2013; p.2609)

2.2.7 Barriers to Making

Gershenfeld has previously described the projects undertaken by users of these spaces as highly individualised, he refers to this as the “killer app” of personal manufacturing, the ability to create products for a market of one (Stacey, 2014). This further enables consumers to become active

[8] The process by which technology is adopted by and diffused into society is discussed in Chapter 3.3.

participants in the design and creation of products that they use. Whilst those who do engage with the maker movement are keen to exploit this potential, there are of course many members of the public who have no wish to do so. As Toombs et al. (2015) point out, whilst the general rhetoric of the maker movement is one of inclusivity, this may be obscuring the facts that not everybody can be a maker, due to a wide variety of physical, economic and socially limiting factors, i.e., material/transportation costs. And so, in contrast to the positive image that the maker movement presents, it could in fact simply sustain, or even exacerbate existing social inequalities (Donohue and Marsh, 2019). Whilst there are an increasing number of academic papers and articles that reference the potential impacts of the maker movement, there is currently a lack of empirical work to support these conclusions either way.

2.2.8 The Democratisation of Technology

Whilst the maker movement has received a great deal of attention for its role in promoting 3D printing, the maker movement itself would not have been possible had it not been for the emergence of *open-source design* and *open-source manufacturing.* Philosophers of technology have long since argued for the democratisation of technology (Winner, 1995; Feenberg, 1992), meaning that all who have a stake in the development of a technology can exert influence over it. Prior to the introduction of FabLabs and Makerspaces, users wishing to 'Hack' existing products or experiment with modifications that required expensive and or hard to use tools, were severely hindered by the lack of accessible facilities. As the cost of digital fabrication tools has decreased, these tools have made their way into makerspaces, where users now have a much broader, and sophisticated suite of tools (Mota, 2011). Users are further aided by the current economy which thrives on obsolescence, generating a surplus of 'disposable high-technology' that greatly lowers the costs of hacking and experimentation (Blikstein, 2013; Tanenbaum *et al.*, 2013).

The rise of the maker movement means that the creation of innovative software, new forms of interactions and new processes for physical prototyping are no longer the preserve of well-funded professional designers and researchers (Tanenbaum *et al.*, 2013). This has only been made possible by the introduction of *peer-to-peer production*, and *open-source design and manufacturing*. These are technological developments which stimulate new social and institutional arrangements, such as digital networks, which have afforded the creation of new forms of organisations that are more geographically distributed, and as a consequence have enabled a more globalised economy (Brey, 2017).

2.2.9 Social Innovation

The approach of open-design and open-manufacturing can be thought of as a form of *Social-Innovation*, which can be defined as new ideas (products, services and models) that simultaneously meet social needs (more effectively than alternatives) and create new social relationships or collaborations. These are innovations that are not only good for society but also enhance society's capacity to act (Hubert, 2010; Johar *et al.*, 2015). Social Innovation is increasingly being viewed as a strategy with the potential to solve some of society's most difficult problems at local, regional, national and global levels (Johar *et al.*, 2015). Open-design and open-manufacturing are an evolution of the open-source software approach, which include open exchange, participation, rapid prototyping and community.

As the rise of the internet made possible open-source software, it is the emergence of accessible digital fabrication that provides the technical underpinning of the maker movement. Digital modelling and fabrication combine design with production through the use of 3D modelling software (CAD), and digital additive/subtractive manufacturing processes. The tools and equipment provided by FabLabs and makerspaces provide makers with a whole suite of capabilities for additive or subtractive manufacturing. In much the same way that its digital predecessor saw the disruption wrought by personal computers and online co-creation, much of the energy and innovation of the digital fabrication revolution is being driven from the bottom up (Menichinelli and Molina, 2018).

It was the increased access to digital fabrication technology that underpinned the maker movement (ibid.). In the case of 3D printing, this certainly would not have been possible had it not been for open-source development. The first consumer printers were created in 2004 by Adrian Bowyer who called his device the RepRap (replicating rapid prototype). This inspired the creation of MakerBot *Industries* in 2009, the first company based on RepRap's open-source technology. They were followed by Ultimaker in 2011 and Prusa Research in 2012, who both continue to develop open-source hardware and software, which are repeatedly amongst the most used consumer models on the market. This has proven the success of the open-source approach for the design and development of technology. More importantly perhaps, for the successful diffusion of 3D printing into society, this open-source approach also provides a global community of users who are very willing to share their experiences, ideas and 'hacks' for this technology.

2.2.10 Summary

The maker movement has provided a global network of users and the physical spaces which have helped support the development of consumer 3D printing. In the maker movement, the consumer 3D printing industry has found a very large group of early adopters who have helped test, develop and further promote the capabilities of 3D printing technology. Whilst not everyone will identify with the maker community, these early adopters do provide a wide range of case uses which provide an insight into how this technology can be used in our everyday lives. Though, there is clearly a widening gap between the capabilities of 3D printing technology as portrayed by popular media, and the reality of the technology as experienced by its users today.

2.3 Part 2: Existing Futures

2.3.1 Social Imaginary

This research is concerned with uncovering and understanding the expectations and anticipations surrounding the future of technology, specifically 3D Printing technology. As such, this research is situated within the futures field of study, which goes by many different names, but here it will simply be referred to as futures, in recognition of “the existence of many potential alternative futures, rather than simply a single future” (Voros, 2022: para.10). In much the same way that futures studies consist of a vast array of studies and approaches, even being referred to as a “very fuzzy multi-field” (Börjeson et al., 2006: p.723), the process by which a technology is successfully adopted and diffused into society is also a complex one. Successful adoption is dependent on the decisions made by a broad range of potential users (the general public) and these decisions are not simply influenced by the design quality, build quality or the functionality of the technology in question (Straub, 2009; Adler and Clark, 2008; Rogers, 2003). An important matter of concern for understanding both futures and the successful adoption of technology is therefore the way in which they are perceived.

When discussing the work of Pinto and his explanation of *futurology*, Gonzatto et al. (2013) describe how Pinto was deeply critical of the widely accepted formalist approach to understanding human existence. This formalist approach was a linear perspective, whereby history is accepted and lies in the past, reality is governed strictly by experiences in the present, which leaves the future to the realm of fictional speculations [Fig. 2.4]. Viewed in this way, with the past determining the present, any changes to the status quo could only occur in the future, and then only as a hope, rather than as fact. Gonzatto et al. (2013: p.38) go onto explain that Pinto considered *futurology* to be future visions that do not consider changes in social structures, or “visions that do not close the loop”. Pinto instead saw both the past and future as shaped by the present, resulting in a present which is in a state of constant change [Fig. 2.5]. Viewed in this way, each moment is an opportunity for every person to “design the future that they imagine and the past that they believe has happened” [ibid.: p.38]. This notion resonates with the work of Law and Urry (2004) who describe a plurality of pasts and futures, each individually constructed to create our own individual realities.

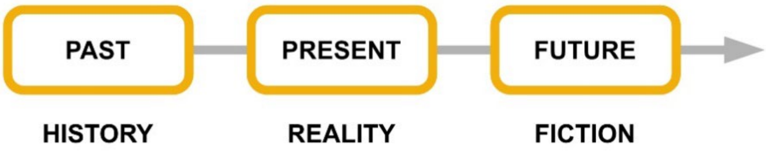


Figure 2.4 The formalist approach to understanding human existence – This is a deterministic linear view for understanding human existence, in which the past determines the future, to maintain the status quo (Gonzatto et al., *2013).*

These collective individual realities create what is referred to as the *social imaginary,* a term first used by Castoriadis, writing under the pseudonym Paul Cardan in the 1950s, who went on to write *The Imaginary Institution of Society* (1975)*,* in which he explained that society is not a given, but instead only exists because it is collectively imagined in certain ways. The social imaginary therefore is comprised of the values, institutions, laws and symbols common to society through which individual people imagine their social whole. Castoriadis was influenced by the work of Durkheim, a sociologist who described collective representations as the glue that holds societies together (Gilleard, 2018). Taylor describes social imaginary as the manner by which people "imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie all these expectations" (Taylor, 2004: p.23). Taylor's work is concerned with understanding how 'ordinary people' imagine the social "and this is often not expressed in theoretical terms, but is carried in images, stories and legends" (ibid.), in this way imaginaries are shared by large fractions of society (O'Neill, 2016). These narratives and images are not only constructed by society, but they can also be used to influence society. When discussing the idea of *Real Utopias*, Wright explains that "what is pragmatically possible is not fixed independently of our imaginations but is itself shaped by our visions" and goes on to say that "self-fulfilling prophecies are powerful forces in history" (Wright, 2015: p.4). This enforces the importance of these shared images, stories and legends, as these can be highly influential in shaping the future that society strives for (Weber, 2020; Stein, 2017).

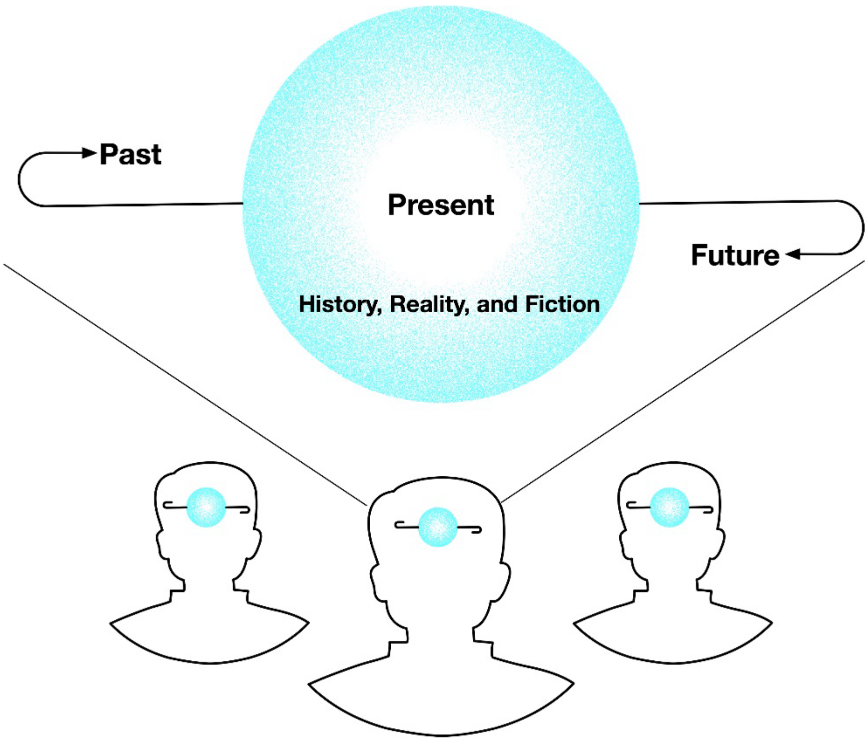


Figure 2:5 History as the possibility of redefining past and future as described by Pinto, Paul Coulton, 2020 –This also indicates the plurality of individually constructed realities.

Technology companies exploit this by sponsoring visions of the future in which they themselves feature heavily, their primary intent being to "nurture consumers into consumption habits and convince investors of their capacity to fulfil those same demands" (Gonzatto et al., 2013: p.39). Another criticism of these corporate visions is that they typically maintain "current social paradigms" and "avoid negative facets of their proposals with seductive imagery, borrowing from science fiction language" (ibid.: p.41).

The social imaginary is therefore highly complex but can be understood as "the creative and symbolic dimension of the social world, the dimension through which human beings create their ways of living together and their ways of representing their collective life" (Thompson, 1984: p.6). In contrast, futures presented as a result of corporate foresight or visioning exercises, represent a singular future, one in which the company in question plays a key role and everything is bent to their own purpose. This research presents the social construction of imaginaries as an alternative approach to these corporate visions, in order to question the preferable future role of technology, which in this instance is 3D printing. This research makes use of the relatively new design paradigm of design fiction, to question rather than maintain the status quo (Dunne, 2005), by creating a design space which can be "free from market pressures and available to explore ideas and issues" (Dunne and Raby, 2013: p.12). Taking this approach allows for the creation of socially constructed future imaginaries, speculations of the technological expectations and anticipations of society.

2.3.2 Existing Portrayals of 3D Printing

It has been established that there exists influence between science, scientists and cinema (Kirby, 2013), and by extension science fiction literature and television. One of the most famous examples of this is the seminal Stanley Kubrick film, *2001: A Space Odyssey (1968)*, the screenplay for which was co-written with Arthur C. Clark and has been referred to as the most scientifically accurate film ever produced (ibid.). Arthur C. Clark was a *Science Fiction* writer who adhered to the principles of *Hard Science Fiction*, a term used to describe *science-fiction* with a concern for scientific accuracy and logic. However, not all writers and film makers adhere to these principles. Works which have no real basis in science are therefore referred to as *sci-fi*, or *science fantasy*. Highly successful examples of this are the Star Wars and Marvel Cinematic Universe franchises, whilst they do lean heavily on ideas of future technology, they make little effort to keep one foot in reality.

It is perhaps unsurprising then, considering the volume of media attention that 3D printing has received over the past decade, that the potentials for 3D printing technology in the future have been explored by many novels, television shows and films. This is important as it has been shown that "filmic portrayals of technological possibilities" can "stimulat[e] desire in audiences to see those possibilities become realities" (Kirby, 2010a: p.43). However, in the case of 3D printing this has most often been carried out not as an exercise in *Science-Fiction*, with scientific advisors onboard, but has instead been carried out as an exercise in *sci-fi*, with little concern for scientific accuracy or logic. Whilst this may not seem important or problematic, as Kirby explains "[e]ven film-makers who have no vested interest in seeing the real-world development of a technology play a role in how these technologies are depicted on the screen" (ibid. p43). Whether intentional or not, the way in which 3D printing technology is portrayed in the media has an impact on the social imaginary. Even for those examples that do portray 3D printing technology as well established and embedded in the everyday mundanity, the simple fact that the use cases for it far exceed the capabilities of the technology as we understand it today, contributes to the overinflated expectations for prospective users. Whilst it may seem arbitrary to criticise misleading depictions of 3D printing in a genre of fiction, the issue is that unless the viewer has first-hand experience with this technology, they have no reference to understand which of the capabilities are fact and which are fiction. This further increases the disparity between the expected and anticipated uses of the technology and the real-world capabilities of it, which has a detrimental impact on the adoption and diffusion process (Radas *et al.*, 2005; Straub, 2009; Rogers, 2003). What follows is by no means a comprehensive survey of media or theoretical review but is included to provide a brief overview of literature, television and film that depicts technology, which is referred to as, or is implied to be, 3D printing. This is relevant to the research because science fiction intentionally ignites our imaginations, reflects our fears, and encourages us to wonder what the future could be. Furthermore, science fiction renderings are commonly taken as factual, leading to misunderstandings about technology, its uses, and its capabilities. This phenomenon is explained by the Thomas theorem, stating that "[i]f [people] define situations as real, they are real in their consequences" (Thomas and Thomas, 1928; p.572). Therefore, it is necessary to provide an overview of the mainstream media's portrayal of 3D printing technology to understand the different expectations and anticipations that users may have for this technology.

2.3.3 Visual Portrayals

The most famous example of a '3D Printer' is perhaps the Star Trek Replicator [Fig. 2.6a], which first appeared in the *Star Trek: Next Generation* series (1987-94). Whilst other science fiction writers had speculated about the future development of 'replicating' or 'duplicating technology', the Star Trek *replicator* was the first to use this term (Hollow, 2013). The replicator has also been referred to as a matter compiler, or molecular assembler, as it is able to reconstitute matter to produce anything out of pure energy, assuming the desired molecular structure is on file. So, whilst the replicator technology as presented, shares little familiarity with 3D printing technology as it exists, it has nonetheless been extremely influential, not only to other works of science fiction, but also lending its name to the first mass produced consumer 3D printer, the MakerBot replicator which launched in January 2012.

Fast forward several decades and the concept of 3D printing has become well known, and portrayals of the technology have become more frequent. One such example appears in the opening title sequence to the 2016 television series Westworld [Fig. 2.6b], which features 3D printing heavily throughout. The series is set in c. 2058 and as such the technology depicted is clearly far more advanced than the technology we currently have, but unlike the replicator, it is recognisable as 3D printing. The process shown during the title sequence seems to be an advanced version of stereolithography (SL), a process whereby a platform is submerged in a resin material and ultraviolet light is used to cure the liquid resin, one layer at a time. This indicates the future development of a large-scale vat polymerisation technique. In addition to SL printing, the 'base model' is then worked on further, with detail being added by the process of Fused Deposition Modelling (FDM), or the more recent term, Fused Filament Fabrication (FFF). The print head is mounted on a highly advanced and articulate multi axis robotic arm, depositing fibres of material, seemingly printing muscle tissue and ligaments. So, whilst all of the technology is recognisable as a version of 3D printing technology, it is extremely advanced and used in a combination that is highly improbable, considering the difficulties and constraints of multi-material 3D printing (Meisel and Williams, 2015).

A more modest depiction of 3D printing appeared in the 2018 film *The Cloverfield Paradox* [Fig. 2.6c], which was set in 2028. The device looked like any number of currently available consumer grade, fully enclosed, FDM 3D printers. However, the machine is shown to produce food stuffs, but in later scenes it is shown printing a gun. Whilst it is true that 3D printing technology exists to print both food stuffs and 3D printable guns (Kietzmann *et al.*, 2015),whilst mechanically similar in terms of motion, the devices that do so are very different in terms of how they deposit the material. The speed of the process is another misleading aspect, in reality the speed of material deposition is greatly limited not only by the mechanical speed of the printer itself, but also the print materials specification, and the compatibility of different materials can be a complex challenge (Meisel and Williams, 2015). Assuming the problem of material compatibility could be overcome, another issue with this portrayal is the resolution (quality) of the print being produced at such a rate.

The hyper-sensationalising of 3D printing technology has become so frequent that it has become something of a trope. So much so that when a television series actually depicts the technology in a somewhat accurate manner, it stands out (Nardi, 2018). The series being referred to here is the 2018 remake of *Lost in Space* [Fig. 2.6d] in which a 3D printer is featured in several major plotlines, with most of the main characters interacting with it at some point. Not only is it a realistic portrayal of 3D printing, it is also a highly plausible depiction of its use (Prater *et al.*, 2019). The 3D printer itself appears very similar to present day FDM machines, which is plausible as mechanically these devices have changed very little over the past three decades. The technology is presented as so ingrained into their everyday lives, that no attention is drawn to its frequent use, to produce a variety of replacement parts. When shown in use the device also has similar limitations to the machines of today, such as long print times, meaning that characters often set the printer going and return much later to collect the completed object, this is in stark contrast to most other depictions whereby the object emerges unbelievably quickly in front of the viewers eyes. This is also the only example that shows the object requiring printed support material for a successful print and the subsequent finishing process in order to 'clean up' a model.

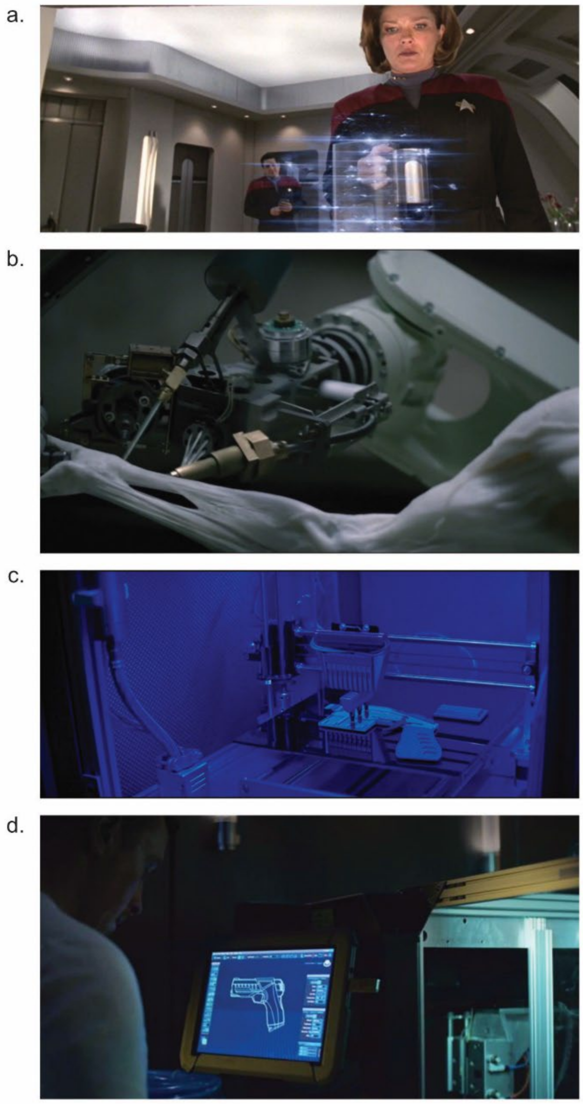


Figure 2.6 Examples of "pop" future depictions of 3D printing in television and film, (Paramount Television Network - 1995), (HBO Entertainment – 2016), (Paramount Pictures – 2018), (Legendary Television - 2018) – A selection of examples showing the future of "3D Printing" as depicted by television and film. a) The Star Trek Replicator, shown here in the Voyager *series. b) 3D Printing features heavily in the opening title sequence of Westworld. c) A key scene of* The Cloverfield Paradox *revolves around the 3D printing of a gun. d). A more realistic depiction of 3D printing as seen in* Lost in Space

2.3.4 Literary Portrayals

The theme of 3D printing has also been explored by a variety of authors, and in most instances these depictions of the technology are even more fanciful than those of film or television. The release of the 1995 novel *The Diamond Age*, by Neal Stephenson was at least a decade prior to the emergence of consumer grade 3D printing and is set in the distant future. It is perhaps unsurprising then that the technology as described does not closely resemble any technology available today. Present 3D printers are rather crude by comparison, capable only of printing mono-materials in a coarse fashion, when compared to the *Matter Compilers* of *The Diamond Age* that deposit materials on a molecular level. These *Matter Compilers* are used to produce everything from clothing to food and tools, but have far more in common with the *Star Trek* Replicator than 3D printing technology as it is understood today.

The 2009 novel *Makers* by Cory Doctorow is set in the near future and was heavily inspired by existing maker communities, and unlike other novels that features 3D printing, the technology and the community around it in this instance is very much the focus of the narrative. Central to the premise is the broad availability of surplus electronics and the ability to hack them into new and novel devices, with 3D printing playing a central role in making this all possible. However, despite the devices themselves being described as similar to the printers of today, the materials they are able to print with imply complex devices quite unlike those available at present.

This is similar to the way that 3D printing technology is depicted in William Gibson's 2014 novel *The Peripheral*. In his near future world, 3D printing is used to produce almost everything. The main character, Flynne, works in *Forever Fab*, a 3D printing shop, producing novel or illegal objects to sell. Everything from knock-off luxury items to methamphetamines is "fabbed" (printed). Again, the 3D printing technology is depicted as an everyday appliance, that is not in the least bit out of place or by any means novel. Little attention is given to describing the *fabber* devices themselves, though there are some clues to suggest a combination of FDM and SL printing, which is the same combination as depicted in *Westworld*.

Emma Newman's 2015 novel *Planetfall* takes place in an unspecified future period, though it does involve colonising of an alien world, so it is safe to assume it is not a near future. The main protagonist is Rey who herself is a 3D printer engineer. From the outset, the use of 3D printing is referenced, though in the story it is simply referred to as printing, indicating how normalised the technology has become. Though the machines themselves are not described in any great detail, the way in which they are used and the range of objects they can create suggests that these are highly advanced machines, capable of complex multi-material printing at a high speed. It is explained that once an object is no longer required it is thrown out, whereby the refuse is collected and sorted, before being "rendered into the base powders they were printed from" and then "sucked back into the communal feeds". Through the course of the story, the printers are used to create almost anything and everything. Such a device as described would once again seem to have more in common with a *Star Trek* Replicator, or matter compiler, than a 3D printer as they can be understood today.

2.3.5 Summary

With very few exceptions, 3D printing is portrayed as being successfully adopted by society and is highly accessible to the point of mundanity. This research has drawn on the representations

In this way these depictions contribute positively towards the social imaginary for 3D printing, unfortunately however, the capabilities of the technology as portrayed by the media are for the most part greatly exaggerated, if not entirely fantastical. Whilst this does contribute towards achieving stage one of the technology adoption process, *awareness,* it could conceivably confuse matters for stages two and three, *persuasion* and *decision* (Rogers, 2003), by providing conflicting information that does not align with reality. This makes it very difficult for potential users to understand the innovation itself, as for those who have little to no hands-on experience with 3D printing, they have no reason to question or doubt the capabilities as described in these fictional narratives. This contributes to a delamination between the expectations for 3D printing and the actual, real-world capabilities of this technology. What are missing then are speculations on the future of 3D printing technology that are not driven by hyperbole but are instead grounded. Constructing plausible depictions of this technology as beneficial to our everyday futures, would contribute positively towards the creation of new and alternative social imaginaries.

This first part of this literature review has provided the contradictory context that this research sits within. It has been necessary to draw upon science fiction as a way to convey how ideas concerning the adoption and widespread use of 3D Printing could (rather than would or should) play out, because the future has not yet arrived. The future of 3D printing technology as advertised by its manufacturers and popular media, portrays it as a potentially world changing and sometimes world creating technology. In stark contrast to this there is the global group of early adopters who have eschewed the hype and have instead created real world use cases for how this technology can be used in the present. The following part of this literature review suggests new approaches to the way in which we produce future imaginaries, as opposed to merely deterministic extrapolations of existing technology or present events.

2.4 Part 3: Alternative Futures

2.4.1 Social Futures

Social futures study is an emergent field within futures studies that tries to get "away from the idea that futures are dependent on or determined by technologies or that they are simply derived from the ways in which the present is unfolding" (Urry and Woodhead, 2015a). When describing social futures, Lopez-Galviz and Spiers state that:

> While economics and technology are important, social futures makes the case for attending to a wider range of social considerations necessary for humanity, other species

> and the planet to flourish, and adopting a broader, more creative, set of approaches and methods in order to do so. (2021, p.1)

They go on to further explain that:

> Futures defined by other values – equality, fairness, justice and inclusivity – require techniques that differ from those used in crafting the futures we learn about through newspapers, newsrooms and reports by think tanks and governments. (Ibid, 2021, p.2)

Emerging futures are contested as they represent different interests which seem to be characterised by 'wicked problems,' with each having multiple potential 'causes' and 'solutions.' The ambition of social futures research is to encourage thinking that is not only in the interest of our current generation, but also future generations, to give a voice to past, present and future societies. This concept of giving a voice to society is a central way in which this research defines social futures.

This research considers social futures to be futures which are equitable and accessible for all, sharing some commonality with the creation of utopias, which is discussed by sociologist Ruth Levitas, who explains that in order to deliver on these potential futures "[w]e need to think about what kind of social and economic system can deliver secure and sustainable livelihoods and ways of life for all" (2013a, p. xii). Achieving this requires us to consider our "conceptions of human needs and human flourishing in those possible futures" (ibid, p. xv). This research uses 3D printing technology as a vehicle to reveal what futures people imagine and how these might manifest. This provides the basis for describing the kind of society that we want, which then allows us to consider how we can sustain and support these futures becoming reality. Social futures are futures as imagined and informed not by wealthy powerful individuals or large corporations, but instead by the everyday people who will inhabit these futures.

One theme within social futures research that is of particular interest to this research is the idea of everyday futures. The term 'everyday' refers to the repetitive and the routine, the future that is already present, with attention being drawn to the "social structures and practices which are perpetuated into the future, through everyday action" (Meadows and Kouw, 2015: p.1). Everyday futures are concerned with understanding how futures can be made in ways that are inclusively beneficial. As Chatterton and Newmarch (Chatterton and Newmarch, 2017) explained, the building blocks of the future already exist today and in the coming years they will create the new 'normal' of the future, unfortunately this will also mean that the same inequalities of today will lead to similar inequalities tomorrow.

The transformative power of technology to "arrange and rearrange contemporary societies" is well established and is the focus of an interdisciplinary field of research called Science and Technology Studies (STS) (Felt et al., 2017: p.1). As Bijker and Law note: "Our technologies mirror our society. They reproduce and embody the complex interplay of professional, technical, economic, and political factors" (Bijker and Law, 1992: p.2). Put simply, designers must proceed in terms of their own understanding of the world, and their ideas have been shaped by their own individual experiences, design education, and demographic positioning. What 'makes sense' to the designer will most likely be in accord with the designers' tacit assumptions, which may not be the same as those persons who are intended to be the end users.

2.4.2 Social Design

It is therefore important that design outcomes that concern the public should also involve the public, that is to say, social futures should be *designed by society* (Whiteley, 1993). This then raises the question "how might design move into public debate, systematic inquiry, and institutional practices in unprecedented ways?" (Woodhouse and Patton, 2004: p.1). When viewed in this way, the development of all technology could benefit from a more inclusive process. This is especially true for new innovations that do not belong to an existing market. Looking at this through a social futures lens, the question then becomes how technological futures can be developed in ways that are "beneficial to those who are often excluded from official narratives of change" (Meadows and Kouw, 2015: p.1). By seeking to engage with as inclusive a range of stakeholders as possible, and involving them in futures research, this not only gives them a voice, but also helps to consider more socially aware futures, by involving those who are not currently involved with 3D printing technology and therefore typically excluded from these discussions.

2.4.3 Understanding Futures

As has already been established (in 1.3 A Brief History of Futures), there are a vast array of studies and approaches within this "very fuzzy multi-field" (Marien, 2002) of futures, which over the last fifty or so years, has moved from attempting to predict the future, to mapping alternative futures, to shaping desired futures. In 1981 Amara (1981) defined three fundamental premises of futures, which have since been referred to as *The Three 'Laws' of Futures*, these are:

1. *The future is not predetermined*.
2. *The future is not predictable.*
3. *Future outcomes can be influenced by our choices in the present*.

Whilst we cannot predict which of the infinitely possible futures will arise, we can nevertheless influence the shape of the future, through the choices that we make, regarding our actions or inactions. Although the "fuzzy concept of 'the future' is always challenging" (Coulton and Lindley, 2017: p.6), there are widely used approaches and ways of understanding futures that help to mediate these difficulties. The contributions of three people within the field of futures studies, whose work has been greatly influential to this research, will be introduced here.

The first is Richard Slaughter, who has spent over four decades working in the field of futures studies, applied foresight and social innovation. Slaughter introduced critical futures studies whereby the act of critique is a central methodology, with the essential aim being to probe beneath the surface of social reality and to question it more deeply (Slaughter, 1998). Slaughter has been a harsh critic of pop futurism and frequently uses critical analysis of futures publications to reveal the underlying discourse or narrative that produced the futures work, along with its limitations

(Slaughter, 1993). He also sought to expand the methodological skill set of futurists beyond predictive forecasting to embrace methods consistent with a wider range of epistemological positions, promoting the exploration of alternative futures rather than a single predicted future (Riedy, 2021).

Slaughter also introduced the notion of 'social foresight' which offered a form of foresight practice free from the confines of established futures studies (Slaughter, 1996). The ambition was for this to become a routine social practice, as Slaughter considered the future too important to be left to private interests or to chance (Riedy, 2021). Slaughters critiquing of futures research led to the development of his layered, depth-based view of futures work which comprises successively deeper levels of futures work: pop futurism; problem-oriented futures work, and critical and epistemological futures studies (FOOTNOTE - Slaughters depth in futures thinking is discussed in greater detail in section 3.5.1) (Slaughter, 2002a).

Slaughters ideas for freeing foresight from private interests resonates with the ambitions for speculative design, which along with his layered, depth-based view of futures work, has been highly influential for this research in helping to locate design fiction and speculative design within the field of futures studies.

The second influential figure is Saohail Inayatullah, a political scientist working in the field of futures studies, who building upon the work of Slaughter, argued that futures studies should be seen as layered, deep and shallow. Inayatullah introduced Causal Layered Analysis (CLA), a research method that did not aim to predict the future, but instead "create transformative spaces for the creation of alternative futures" (Inayatullah, 1998).

CLA takes as a starting point the assumption that there are different levels of reality and ways of knowing, considering that individuals, organisations and civilisations see the world from different vantage points, both horizontal and vertical. CLA consists of four layers, the litany, social causes, discourse/worldview and myth/metaphor, the aim being to traverse through these layers of analysis, to be inclusive of different ways of knowing. Slaughter considered this approach to "provide a richer account of what is being studied when compared to the more common empiricist or predictive methods which merely 'skim the surface'". (Slaughter, 2002b).

These four layers are:

- 'litany'—quantitative trends, problems, often exaggerated, often used for political purposes.
- social causes, including economic, cultural, political and historical factors (rising birthrates, lack of family planning, eg).
- structure and the discourse/worldview that supports and legitimates it (population growth and civilizational perspectives of family; lack of women's power; lack of social security; the population/consumption debate, eg.).
- metaphor or myth. These are the deep stories, the collective archetypes, the unconscious dimensions of the problem or the paradox.

Inayatullah explains that individuals write and speak from differing perspectives and that CLA endeavours to find space for all of them. It is however not intended to be a standalone method, rather it is best used alongside others, such as visioning, which can help create preferred futures (Inayatullah, 1998). Interaction with the process is critical, by moving up and down through the different layers and sideways through the scenarios that this generates, "one can explore levels of responses, decolonise dominant visions of the future and create authentic alternative futures" (Inayatullah, n.d. p.??).

The third major influence for this research was Joseph Voros, who began as a theoretical physicist before moving into the futures studies field and becoming a strategic foresight analyst where he developed the Futures cone. As has previously been discussed, the Futures cone is a development of the work started by Taylor, and Hancock and Bezold. Prior to this, futurists often spoke of three main classes of futures: possible, probable, and preferable (e.g., Amara 1974, 1981; Bell 1997, and many others). Voros however, found that whilst working in foresight, this was too limiting, and so more classes were added [Fig. 2.7]. These in brief are:

- Potential – everything beyond the present moment is a potential future.
- Preposterous - these are the futures we judge to be ‘ridiculous’, ‘impossible’, or that will ‘never’ happen.
- Possible – these are those futures that we think ‘might’ happen, based on some future knowledge we do not yet possess, but which we might possess someday.
- Plausible – those we think ‘could’ happen based on our current understanding of how the world works
- Probable – those we think are ‘likely to’ happen, usually based on (in many cases, quantitative) current trends.
- Preferable – those we think ‘should’ or ‘ought to’ happen: normative value judgements as opposed to the mostly cognitive, above.
- Projected – the (singular) default, business as usual, ‘baseline’, extrapolated ‘continuation of the past through the present’ future.

These seven alternative futures are intended to be subjective judgements about the ideas that people consider about the future, based in the present moment. As such the categories that an idea belongs to can change over time, for example, the Apollo XI Moon landing can be considered to have passed through each of the categories, beginning with ‘preposterous’, the ‘projected and through history into ‘the past’. Viewed in this way, every future is a potential future, including those we cannot even imagine. Of most interest to this research is the class of preferred futures—what ‘should’ or ‘ought to’ happen—which Voros explains:

> …can take in any or all of the classes from preposterous to projected, because these futures must be at least imaginable (so inside the cone), and because people’s idea of what they prefer—and how they judge others’ preferences—can range from the default

projected future thought to be coming all the way outward to (what is considered) outlandish preposterous-ness.

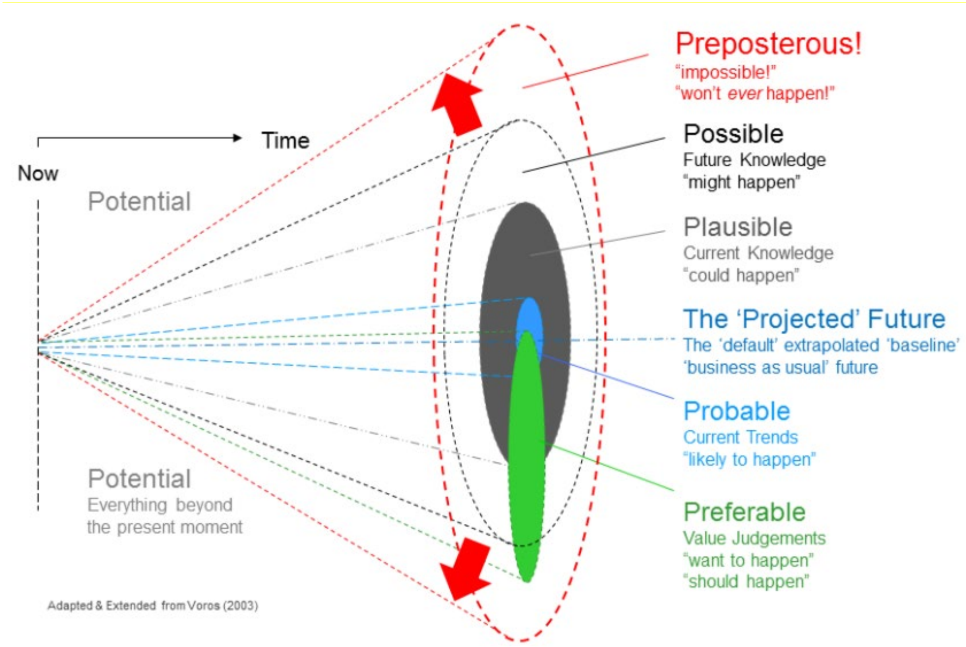


Figure 2.7 Voros' futures cone, Joseph Voros, 2017 (redrawn by author) – This depicts the seven types of alternative futures; Potential, Preposterous, Possible, Plausible, Probable, Preferable, and projected.

It should be acknowledged that the futures *cone* has faced several criticisms, firstly, that there is no universally accepted view of the past, present, or a clear distinction between probable and plausible, these are all highly subjective and individually constructed to create our own reality. This leads to the second criticism, that the category of *preferable* effectively puts the designer of the future scenario in a position of privilege, and without critical reflection on the question of "preferable to who and why?" (Coulton, 2020: p.2), this could result in the promotion of elitist views for what makes a 'better world'. This research is concerned with the preferable and social futures of 3D printing technology, which put simply is what we 'want to' happen, therefore these futures are highly "emotional rather than cognitive" and "derive from value judgements" (Voros, 2022: para.13).

The work of Slaughter and Inayatullah has not only impacted how this research seeks to engage with people in futures research, but also reveals the importance of providing a space for people to share their views and different vantage points. Their approaches provide a way of interrogating and developing the context of the futures being explored. The work of Voros provides a means of positioning these futures along a trajectory, allowing a better understanding of where people perceive these futures to be on the spectrum of futures.

Although Futures as a research field has existed for over 50 years and offers many different approaches and methods, many of these have been developed as foresight methodologies, which are concerned with creating a "high-quality, coherent and functional forward view" and to use the "insights arising in organisationally useful ways" (Slaughter, 2002b: p.1). Though futures visioning is well suited to presenting a *preferable* vision of the future, and uncovering how we can work towards achieving this, these processes are not necessarily appropriate for the questioning of *what* these *preferable* futures - should be - in the first instance. This is where the relatively new field of Design Fiction becomes relevant.

2.4.4 Design Fiction

Large global corporations such as General Electrics, General Motors, Nokia, Microsoft etc. have all presented future technical scenarios that could be considered futurology (Gonzatto *et al.*, 2013). These large corporate 'visioning' projects use design fiction to reinforce their brand identity with technological innovation. Design fiction is a particular form of *futuring*, and whilst it has garnered a lot of attention in recent years, there is no single agreed upon definition of what design fiction is and how to use it. This research follows the paradigm of design fiction as a world building exercise, with no inherent link to 'narrative' or 'storytelling', as described by Coulton and Lindley (Coulton *et al.*, 2017). This is an important distinction to make, as when creating future visions for encouraging debate, it is the scenarios that allow the participants to create their own stories and their own narrative.

The term design fiction was coined by science fiction and cyberpunk author Bruce Sterling when articulating how design had impacted his literary work (Sterling, 2005). Some years later in an interview on this subject, Sterling said "[d]esign fiction is the deliberate use of diegetic prototypes to suspend disbelief about change" (Bosch and Sterling, 2012), which has subsequently become the de facto definition. In the context of design fiction, a diegetic prototype can be understood as a design artefact that seemingly exists within the fictional world that is shown. Diegetic prototypes differ from prototypes as the term diegetic attempts to explain how the viewer should understand and relate to these designs in the fiction, by demonstrating to large public audiences a technology's need, benevolence and viability (Kirby, 2010b). Tenenbaum describes this as using "fictional depictions of future technology to tell a story about the world in which that technology is situated" (Tanenbaum, 2014b, p.22).

These diegetic prototypes serve as entry points into a speculative world as they can infer or signpost specific narratives that help describe the world they inhabit. The term diegetic made its way into the discourse concerning design fiction through Bleecker's influential essay 'Design Fiction: A short essay on design, science, fact and fiction' (2009). Bleecker himself had integrated 'diegesis' into his discussion by drawing on the research of Kirby (2010b), which was concerned with the relationship between science and cinema. The use of diegesis by Kirby simply means "in the fictional world", the use of fiction suggesting a quality of unreality. Following this logic then, Sterling's definition would simply mean prototypes which exist within the unreality of a fictional world, however, if we trace the etymology of 'diegesis', we find that it is rooted in the concept of 'narrative', which has arguably led to an over emphasis on the importance of story and narrative within design fiction (Tanenbaum *et al.*, 2012).

In the same interview with Sterling, he also stated of design fictio*n*, "it creates worlds, not stories" (Bosch and Sterling, 2012), this sentiment is shared by Coulton et al., (2017: p.4) who further this idea by explaining that "these worlds are imbued with a rhetorical intentionality by their creators" and that the “creation of rhetoric within a world rather than through a story allows those interacting with the world to explore the rhetoric of that world rather than being forced down a prescribed path”. Speculative future scenarios produced in this manner, could therefore provide a platform for participants to explore their own narratives within a framework (a speculative world) provided by the designer.

2.4.5 World Building

At this stage it is important to define what is meant by the term ‘world building’, which in this context is the creation of future visions with the intention to showcase or prototype technological concepts (Coulton and Lindley, 2017; Auger, 2013). World building is a powerful approach as it allows the creator to introduce new systems, alternative political realities and provides a window into what it would mean to live within that reality and even offering a possibility of how to challenge the status quo (Zaidi, 2019). This design fiction as world building approach is a deviation from other forms of design fiction which produce artefacts for exhibition in galleries and museums (Auger, 2013). This latter approach to design fiction has faced criticism for failing to deliver on its vaunted potential for “helping people participate more actively”, because it’s “capacity for sustained public engagement is under explored” (Voss et al., 2015b: p.3). The UK government’s Foresight Future event report (ibid.) also stated, “[m]any speculative design projects either operate as stand-alone spectacle, or as engagements with those deemed to have ‘expertise’ – scientist and technologists, political scientists, economists, but rarely wider publics” (ibid.). Further work is needed then in addressing the issue of how to engage with the very public that this method is purported to be concerned with.

In efforts to tackle this criticism, rather than creating physical diegetic prototypes (artefacts) as the focus of the work, design fiction as world building instead appropriates widely familiar formats, some of which are more commonly associated with technology companies, such as promotional material, product videos, device documentation and manuals, such as those shown in [Fig. 2.8] below, which are used to create plausibility (Coulton, 2020; Gonzatto *et al.*, 2013). This is necessary as there needs to exist a bridge between "the audience's perception of their world and the fictional element of the concept" (Auger, 2013: p.2).

It is important to note that the focus on narrative, can *stifle* the flexibility of design fiction, as discussed by Coulton who explained that "these worlds are imbued with a rhetorical intentionality by their creators" and the "creation of rhetoric within a world rather than through a story allows those interacting with the world to explore the rhetoric of that world rather than being forced down a prescribed path" (Coulton et al., 2017, pp. 4-5). Whilst the practices of narratology in futures research is beyond the scope of this research, Raven and Elahi state that the "story is not the world" (2015, pp. 52-53), echoing the thoughts of Sterling, who when discussing design fiction, stated "It tells worlds rather than stories" (Bosch and Sterling, 2012). The world building approach involves designing things that give the impression of a future world, the idea of this world then prototypes these things, with the things prototyping the world, as shown in figure 2.9. This reciprocal prototyping loop allows design fiction to create a fictional world that we can dip in and out of, in order to better understand it (Coulton *et al.*, 2018).

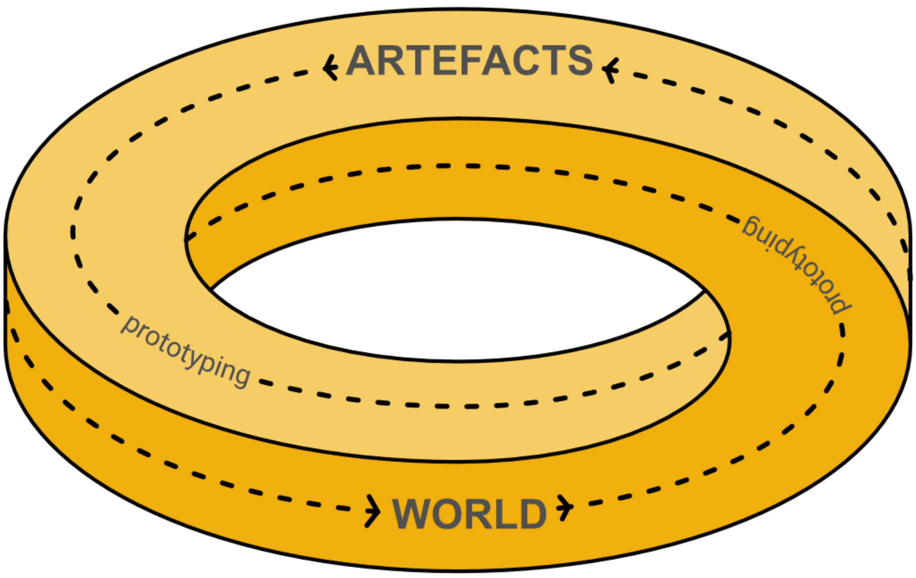


Figure 2.9 This diagram helps to communicate how both world building and diegetic prototypes help to create one another, and is based on the work of Coulton, et al (2018) (redrawn by author).

An important aspect of design fiction as world building is the use of entry points, which facilitate the ability to dip in and out of the worlds. As shown in figure 2.10, each artefact or thing acts as an entry point, these should work together as a collective and feel like they belong to the same world. These entry points operate at different levels of detail, offering both focused views and overviews of the world. In summary, design fiction as world building does not provide people with a specific message about the world that has been created, rather, it shows different views of the world to allow the viewer to decide their own opinion about the future based on their perspective. It is this approach to design fiction that this research is concerned with.

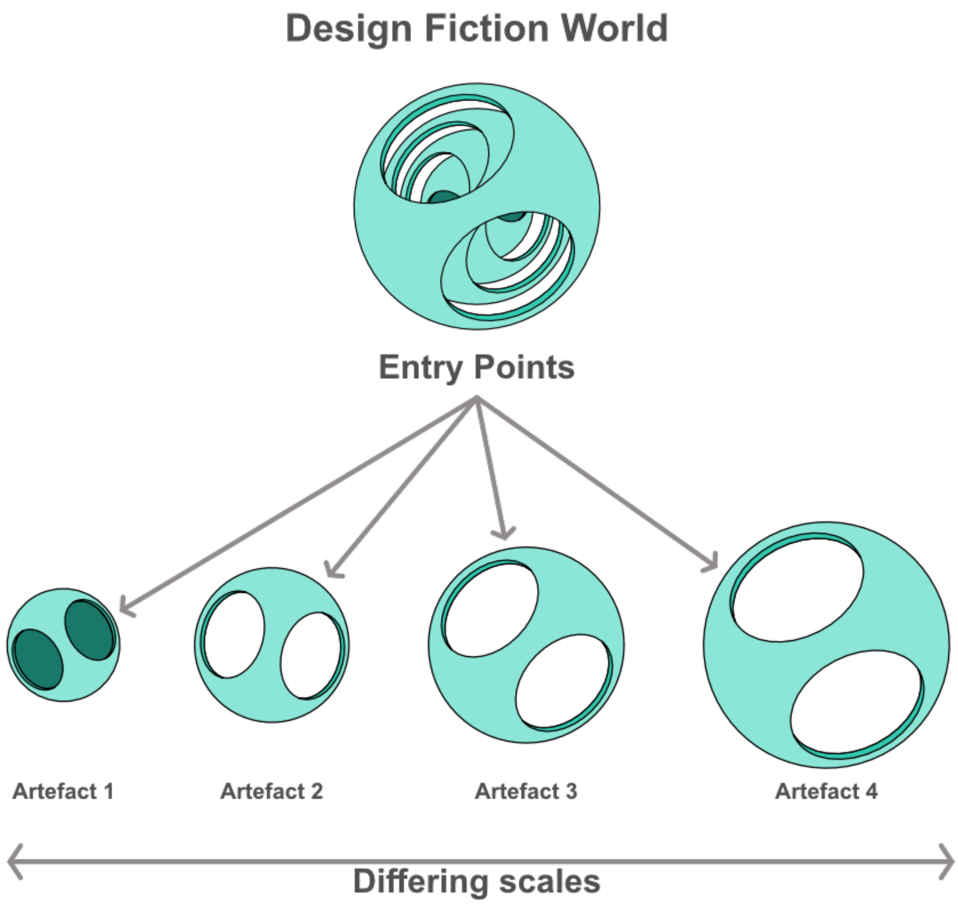


Figure 2.10 several artefacts and their entry points come together (bottom) to form the whole view of the world. Each of the holes in the spheres is a visual metaphor for an entry point into the Design Fiction The different sizes of sphere represent how zoomed in or out each the entry points may be. Based on the work of Coulton, et al (2018) (redrawn by author).

2.4.6 Vapourworlds

It has already been discussed how science fiction writers and film makers have taken the idea of 3D printing and run with it, describing and presenting all manner of fantastical devices which often bear little resemblance to the technology as it exists. Whilst working in the field of science fiction (with a little ‘s’) is a license to explore the unknown, there are also some works of design fiction *world building* which unintentionally stray into the realm of pure fantasy. Coulton and Lindley (2017) refer to these as vapourworlds, a term derived from vapourware, which is commonly used to describe an announced piece of software or hardware that never makes it to market (Atkinson, 2013). Vapourware occurs when the expectations or aspirations for a technology are, unbeknownst to them, simply beyond the ability of the designer or organisation to deliver.

Figure 2.8 Ikea catalogue from the near future, Near Future Laboratory, 2015 *–An example of design fiction world building by the Near Future Laboratory, which was created to ‘spark a conversation regarding the futures of connected things’.*

This has led to instances whereby the concept of *vapourware* has been adopted as corporate ‘visioning’ projects. These depictions present technology and products as enablers of a ‘better’ future, in order to stimulate future demand, and being that this can deter competitors from developing a similar product, it can be considered advantageous to preannounce a new technology untruthfully (Ofek and Turut, 2013).

However, in order for vapourware to 'make sense', an appropriate context is required, which results in the creation of a vapourworld, such as the example in [Fig. 2.9] below. These visions are very successful at showing technology being applied in various ways, speculating on how the application of new technology could impact the everyday lives of those situated within this speculative future (Bleecker, 2015). As Rose (2020) points out however, not only is the technology often vapourware, in many instances of smart city visions, there is not even a specific product or technology being promoted, rather they are merely offering an idea of what the future could be. Rose (ibid.) also highlights that many of the corporations responsible for producing this type of imagery have also developed active social media profiles, where they promote what should be considered not simple advertisements, but remarkably coherent visions, which act as "cultural imaginaries for particular industrial futures" (Maze, 2019: p.27).

The objects and artefacts produced through the practice of design fiction are diverse and varied, but the end point is always the creation of a fictional world. Within a single design fiction, the specific media and forms used should be considered as a collection of standalone artefacts, which together build the world. Each of these artefacts, that contribute to making up this design fiction, is a metaphorical entry point into the fictional world, with each artefact being a representation of that world, at differing scales, providing the backdrop for human experiences as well as the mundane and everyday lives (Zaidi, 2019). The artificially built world is therefore a prototyping platform for the very designs that define it, and in turn these designs prototype the world.

Whilst both design fiction and vapourworlds create fictional worlds, where the two deviate is the intent, as Coulton and Lindley (2017: p.5) explain; whilst it is not necessarily restricted as such, design fiction is typically "concerned with the near-to-medium term technological futures" and as such the "worlds they build are prototyping environments for technological concepts." Whereas vapourworlds are predominantly created by corporations, the primary concern of which is generating a profit, and so whilst they may successfully communicate grand visions and present positive narratives about the future, this is all done for profitability. Design fictions on the other hand "implicitly have an elucidative edge. Being exploratory and inquisitive is a definitional characteristic." (ibid., p.6)

Figure 2.9 A Day Made of Glass... Made Possible by Corning, Corning, 2011 (1:05) – This was Corning's vision for the future, with speciality glass as the central theme, which is perhaps unsurprising considering they are a technology company specialising in glass and ceramics. The 5:32 film depicts a day in the life of a family of four as they go about their everyday routines, surrounded at every stage by interactive glass displays, showing the possibility of a future in which the Corning company has become entrenched in every aspect of day-to-day life. This is an example of a vapourworld as this vision is more fantasy than reality.

2.5 Conclusion

As has already been discussed in section 2.2.1, the future of 3D Printing, as promised by 3D Printer manufacturers and widespread media has not yet materialised. Writing for Wired in 2012, Chris Andersson predicted that "[b]y all evidence, 3-D printing has reached its inflection point... Soon, probably in the next few years, the market will be ready for a mainstream 3-D printer sold by the millions at Walmart and Costco." (Anderson, 2012) Despite the predictions that 3D printing would be widespread and would have long since been adopted domestically, it is fair to say that we are not utilising this technology to the extent that it has been predicted [9]. Although 3D printing has not yet changed our everyday lives, this has not prevented writers and directors exploring the theme of 3D printing, and as such, there already exists an increasing variety of "Pop" futures, visions and narratives. Unlike the work of writers working in *Hard Science Fiction*, these examples fall into the *sci-fi* category, and are in most instances a fantasy, rather than being informed by the reality of 3D printing technology. Whilst the majority of the examples that have been discussed do present 3D printing technology as normalised and engrained into everyday life, the ways in which the technology is used, and the capabilities that it exhibits are far from representing a *plausible* everyday future. Despite the media attention and excitement that has surrounded this technology for the past decade, and the support provided by the *maker movement and associated open-source developmen*t, it is difficult to see these as anything other than failed future visions, and as such can be considered *vapourworlds*. This is an area then that would benefit from new means to create, present and interrogate the ideas of what the future social imaginaries of 3D printing could look like.

This research explores and provokes the existing but contested futures of 3D Printing by engaging with makers, makerspaces, and non-makers to understand the existing social imaginaries surrounding this technology, to build and evaluate alternative ones. Producing socially driven future visions is not necessarily concerned with discovering *plausible* or *probable* futures for 3D printing, but instead facilitate a discourse to interrogate what people's anticipations and expectations are for this technology, working towards uncovering the *preferred* social *futures* of 3D printing. The emergence of the maker community alongside consumer 3D Printing has undoubtedly had an impact on this technology gaining a foothold in certain social circles, but they represent only a relatively small portion of society.

[9] Extrapolating data from the 3D Hubs 2020 trend report, Filamentive (a UK filament manufacture) estimated that by the end of 2021 there would be 232,000 3D printers installed in the UK, out of an estimated 28.2 Million households in the UK.

The inclusion of end users in the design process has been an increasing trend over the last half century and is commonly referred to as co-design or participatory design (Sanders and Stappers, 2008). Unsurprisingly there is already a body of research interested in the use of co-design and participatory design to develop design fictions and speculative designs, or developing design toolkits and workshops to better facilitate the process (Tsekleves *et al.*, 2017; Morrison and Chisin, 2017a; Ahmadpour *et al.*, 2019; Oliver, 2019; Baumann *et al.*, 2018; Rozendaal *et al.*, 2016). These examples all follow a similar process, whereby a series of workshops or engagement sessions are held, which inform the design of a series or singular diegetic prototypes (such as in figure 2.10 below), which then become the focus of further discourse. The artefacts that result from these processes are intentionally provocative to elicit a response, with participants speculating on how they could potentially use this device and the impact it could have on their lives.

Figure 2.10 Curate-a-life and Weighta (left to right), Qualified Selves project, 2019 – *These are examples of co-designed diegetic (prevocational) prototypes, created as part of the Qualified Selves research project.*

Existing iterations of the futures cone diagrams provide the means of visually describing the positional relationship between these alternative futures. These diagrams were created in an effort to define a range of plausible futures, extended over an explicit timeframe. Examples of diegetic prototypes and design fictions would typically be designed in response to a specific futures scenario or alternative future. Rather than working within these defined areas, this research positions the social imaginary as an amorphous 'fuzzy' entity that can exist across multiple futures (as shown in figure 2:11), allowing these alternative futures or scenarios to be explored by the individual constructing their world. The *social imaginary* is a space in flux, that permits experimentation outside of the defined boundaries.

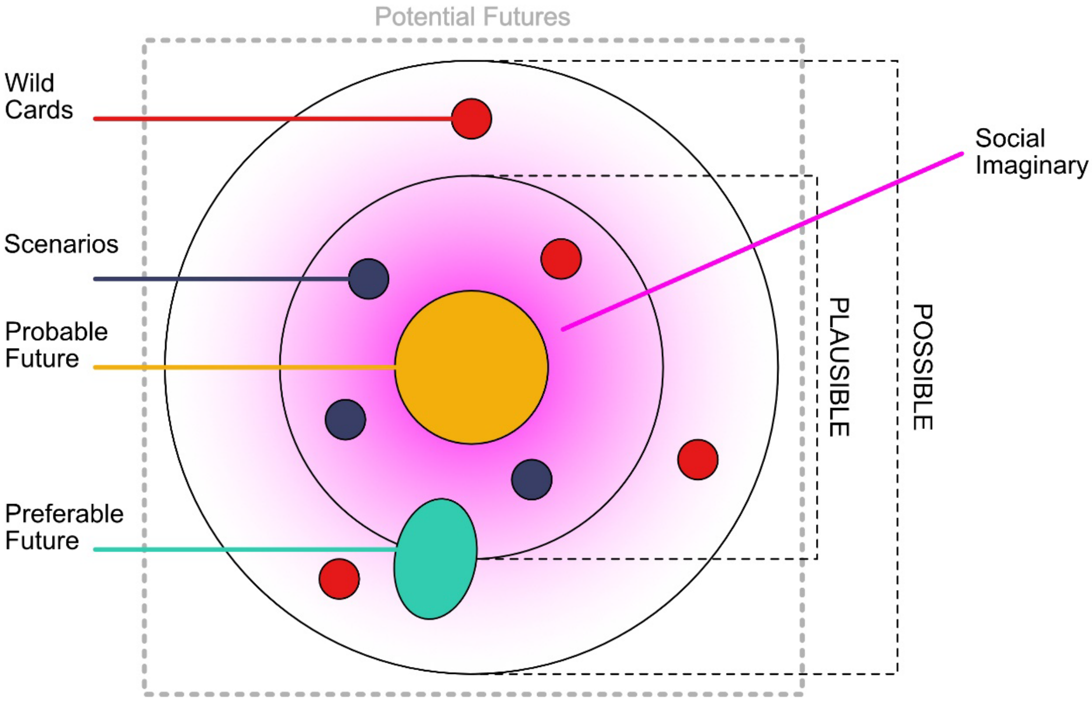


Figure 2:11 Diagram of the social imaginary and the seven types of alternative futures – This research positions the social imaginary *as an experimental space for exploring multiple* alternative futures*. Rather than working within specific areas of* futures, *the* social imaginary *is not defined or constrained by a range or boundaries, allowing greater freedom for exploring what is possible, preferable or probable etc, for those who are doing the world building.*

Where this research differs from the examples of design fiction that have already been discussed, is that rather than present a technological artefact for discussion, it is instead the world around the artefacts which are discussed. For example, 3D printing is not the focus, instead it is the world that 3D printing technology could make possible. By approaching design fiction in this way, these socially informed, *alternate imaginaries* for the future of 3D printing, provide a scaffolding, with multiple entry points, around which each participant can construct their own world and contribute to the discourse on how this technology could impact our everyday lives.

Taylor (2004) described how the *social imaginary* is informed and carried in images, stories and legends, and Wright (2015: p.4) explained the importance of having a “vital belief in a utopian ideal” if people are to attempt a change to the status quo. It is therefore necessary that we have methods for creating aspirational *social imaginaries* that are free from commercial interest and instead are driven by the social. Whilst there is no shortage of fantasy depictions for 3D printing technology, these are relatively unhelpful at providing futures to strive towards.

This research considers Social Futures to be futures which are equitable and accessible for all. When discussing the creation of utopias, Levitas (2013a, p. xii) explains that in order to deliver on these potential futures “[w]e need to think about what kind of social and economic system can deliver secure and sustainable livelihoods and ways of life for all.” Achieving this requires us to consider our “conceptions of human needs and human flourishing in those possible futures” (ibid, 2013a, p. xi). This research uses 3D printing technology as a vehicle to reveal what futures people imagine and how these might manifest. This provides the basis for describing the kind of society that we want, which then allows us to consider how we can sustain and support these futures becoming reality. Social Futures are futures as imagined and informed not by wealthy powerful individuals or large corporations, but instead by the everyday people who will inhabit these futures.

3.0 Theoretical Framework

3.1 Introduction

This research uses the lens of *social futures* to explore alternative visions for emerging technology. These visions, or speculative artefacts, are intended as flexible framing devices, scaffolding around which each individual viewer is empowered to build their own world. This research therefore uses a mixture of research theories and approaches as a pragmatic way to achieve these aims. This chapter will describe the concepts and theories that are used to form the theoretical framework for this research, and will introduce and explain the reasoning behind each of the chosen theories and how they relate to one another. Whilst this research is ultimately a qualitative study, this chapter will outline the measures that have been taken to ensure that where possible all decision making and interpretation of the data is meaningful and can be justified. Chapter One described how this thesis can be understood in three parts, A, B and C, which each having their own approaches and methods, that have influenced and informed this research. These are:

Part A-C – Critical Reflections

Part B - Science and Technology Studies

Part C - Futures Studies

The adoption and diffusion of a technology into society is a complex process, influenced by many external and social factors, which has necessitated a combination of methods. The first approach to be introduced is Science and Technology Studies, which this research uses as a series of critical lenses, providing a framework for making sense of the findings from several data gathering sessions (wide data gathering exercise).

These findings are then used to inform a series of graphic social futures, visions that represent possible social futures involving 3D printing technology. These have been inspired by the speculative design practice of design fiction and borrow from the *future mundane* approach. Combining these practices results in an approach that is informed by both sociological and technological theories.

3.1.1 Process Overview

This research proposes a method for the construction of speculative visions that are created using user driven data, whilst each element of this process will be explained in greater detail over the course of this chapter, a brief overview of how and why this process has been developed will be provided now for context.

The first stages of the process are the data gathering sessions, which were used as wide information gathering exercises intended to provide a baseline understanding of the future expectations and anticipations, concerning 3D printing technology, that are currently held by the public. With the intention of visualising speculative future scenarios, it was not sufficient to merely visualise what had been discussed in these data gathering sessions, especially considering many of the conversations that took place were highly fantastical in nature. As will be discussed, the author of this research is drawing upon personal experience and an established understanding of 3D printing and its applications, however, it is important to acknowledge that these personal experiences could also introduce bias into the process. It was therefore necessary to introduce a means of critically reflecting and interpreting the findings from the data gathering sessions in an impartial manner. To achieve this a series of critical lenses were introduced, through which these findings could be viewed and understood. These provided an understanding of the processes and social mechanisms by which technology is or is not successfully adopted by society. This understanding could then be applied to the planning method of backcasting, which begins by defining a desirable future and then working backwards to identify what steps need to be taken to achieve this. This process helps to rationalise and quantify the decision-making process for what is included and, just as importantly, what is excluded from the graphic social futures.

3.2.2 Data Gathering Sessions

The data gathering sessions were designed to reveal peoples current understanding of 3D printing technology, and to discover what expectations and anticipations they held for this technology in their future lives. This was a necessary step because although the author of this research has tacit knowledge and understanding of 3D printing, this research is concerned with understanding the expectations and anticipations that the public held for this technology. These data gathering sessions would therefore serve to establish a baseline understanding that was not influenced by unfounded assumptions, confirming or disproving the suspected disconnect between people's perception of this technology and the reality of the technology.

The data that was collected from the data gathering sessions was then carefully analysed and critically interpreted, with the findings being used to inform a series of illustrated speculations for exploring possible *social futures* of 3D printing technology. The resultant graphic social futures provide a platform for further discourse with the public, by providing shared visions as a focus.

Though there have been innumerable impromptu data gathering sessions, carried out with friends, colleagues and fellow users of local makerspaces, the data gathering sessions now being referred to are those which were intended specifically for large scale data gathering. There were three of these major data gathering sessions, each of which will be described in greater detail in their corresponding chapters (Chapters Four, Five and Six). These data gathering sessions took place at the *Bluedot* science festival and across several FabLabs and makerspaces in the North West of England. The intention of these sessions was to engage with a range of people who may or may not already be familiar with 3D printing technology. The first of these data gathering sessions (Chapter Four) was designed to be a quick-fire workshop and public discussion, the second session (Chapter Five) was a questionnaire, and the third session (Chapter Six) was a series of interviews. These sessions were used to gather data from different perspectives of users, ranging from those who have no experience of 3D Printing, to those who manage *FabLab*'s and *makerspaces* who not only use this technology daily, but also engage others with this technology and can provide current use cases.

It was important to develop a means for quantifying and making sense of the findings in a manner which could be replicable and understood by others who may not have previous experience with the technology being discussed. In an effort toward achieving a transferable process, a series of critical lenses were employed as a means of guiding the critical appraisal, as explained in figure 3.1 below.

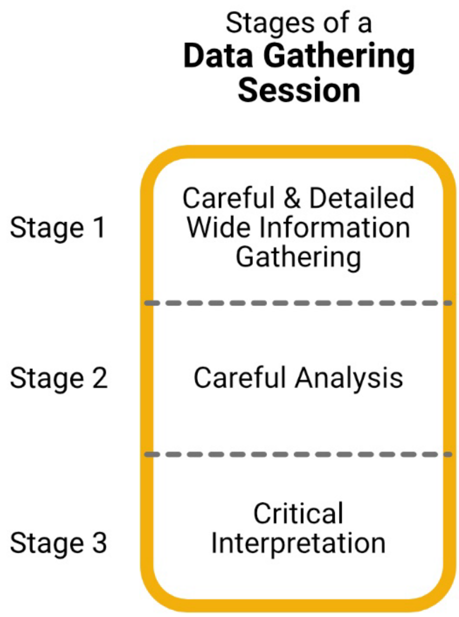


Figure 3.1 Three stages of a data gathering session – Each session comprises three stages, the first stage is data gathering, followed by analysis of the collected data, and then the interpretation of the analysed data. The findings from these data gathering sessions are then used to inform both the subsequent data gathering session and the graphic social future visions.

These critical lenses were taken from Science and Technology Studies [STS] (which will be discussed in the following section) and are used as to aid in the analysis and critique of the sessions collected data. These lenses are also used to inform the data gathering sessions themselves, ensuring that appropriate questions are being asked. Used in this way [Fig. 3.2] each data gathering session creates data sets that contribute towards the design of the final visual speculations, but also allow for the use of feedback loops, with the findings helping to shape the subsequent data gathering sessions.

After each of these data gathering sessions was completed, all the data was collated and coded ready for analysis. For the first two sessions this involved the use of Tableau, a data visualisation software, which was used to better understand any shared trends or patterns that were emerging across the data sets. The results from the final data gathering session, once fully transcribed, were analysed using NVivo, which is a qualitative data analysis application. This enabled the search for subtle similarities of language used across the interviews to better recognise the subtle nuances of the interview responses, such as sentiment.

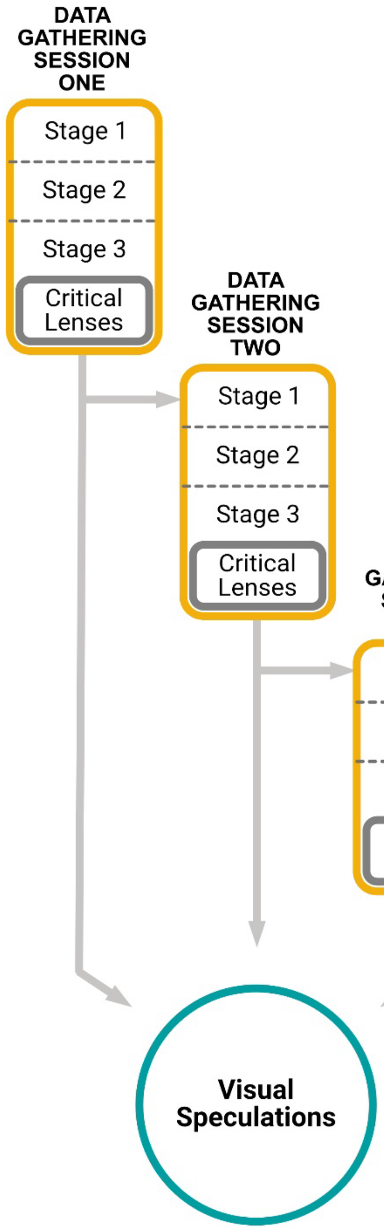


Figure 3.2 Diagram explaining the process of how consecutive data gathering sessions are used for producing socially constructed graphic social futures – This relationship diagram shows how critical lenses are used within the data gathering sessions to inform the visual speculations. The design and analysis of each session has made use of a different combination of Science and Technology Studies theories (it is for this reason that they are simply referred to as critical lenses). The critical lenses are used as part of the third stage of each data gathering sessions, which is the critical interpretation of data. By using them in this manner the critical lenses are not only able to help make sense of the findings, but are also able to highlight areas of interest, or areas which would benefit from further attention and focus in the subsequent sessions.

3.3 Critical Lenses

The critical lenses that this research uses have been borrowed from Science and Technology Studies [STS], which is the study of the social shaping of technology. STS is concerned with understanding why some individuals chose to adopt a technology whilst another may resist, and what are the influences of social context on these decisions? These questions are addressed within the context of adoption and diffusion theory. Adoption theory examines an individual and the choices they make to accept or reject a particular innovation. Diffusion theory examines the spread of an innovation over time, which is the result of individuals making adoption decisions (Straub, 2009). In the research paper *Understanding Technology Adoption*, Straub describes several key innovation and adoption theories and draws three main conclusions.

> Firstly, technology adoption is a complex, inherently social, developmental process; secondly that individuals construct unique (but malleable) perceptions of technology that influence the adoption process; thirdly successfully facilitating a technology adoption needs to address cognitive, emotional, and contextual concerns. (2009: p.625)

By tasking members of the public with considering how the introduction of a new technology could impact their lives, we are beginning to engage them in futures thinking. Not only can we then uncover their cognitive, emotional, and cognitive concerns for the technology in question, but we can also begin to expand upon these alternative imaginaries that are presented to us.

3.3.1 Critical Lens 1 - Adoption/Diffusion Theory

As there is no single all-encompassing method for understanding the process by which an individual chooses to engage and adopt a new technology, I will be referring to these theories collectively as *adoption-diffusion theories*, as the discourse concerning the efficacy of one method over the other is beyond the scope of this research.

Although the approaches of adoption and diffusion theories differ, they all accept that the adoption process is far from being a single event. Whereas the decision to adopt or not to adopt an innovation can be a one-time event, this decision does not take place in isolation and will be informed by an individual's beliefs and attitudes which are formed over time (Straub, 2009). There is also an implicit pro-adoption bias to all adoption and diffusion theories, so much so that when adoption does not occur, this is considered a failure of the diffusion-adoption process, or non-diffusion as Rogers would say (Rogers, 2003).

Though the different theories offer different scopes and perspectives on the process of an individual's decision making, they all share three categories of characteristics that influence the adoption and/or diffusion of an innovation. Individual characteristics are those that predispose individuals to embrace or shun change. Innovation characteristics relate to the innovation in question, how easy is this new innovation to use, and how compatible is it with their current lifestyle. Lastly there are contextual characteristics which comprise the environment and surroundings of an individual during the adoption process (Straub, 2009).

3.3.2 Critical Lens 2 - The Five Stages of Adoption

It has already been stated that there is no single theory for understanding the process of adoption and diffusion, however, the 1962 work of Everett Rogers, *The Diffusion of Innovations* (Rogers, 2003) is one of the most influential books in explaining how an innovation infiltrates a population. In Innovation Diffusion Theory (IDT) the adoption process is inseparable from the diffusion process, adoption being viewed as a subprocess of diffusion. As such, when discussing adoption, this is in terms of its role within the diffusion process.

Rogers sets out five stages of the adoption decision process that an individual goes through during their evaluation of an innovation, as shown in figure 3.3 below.

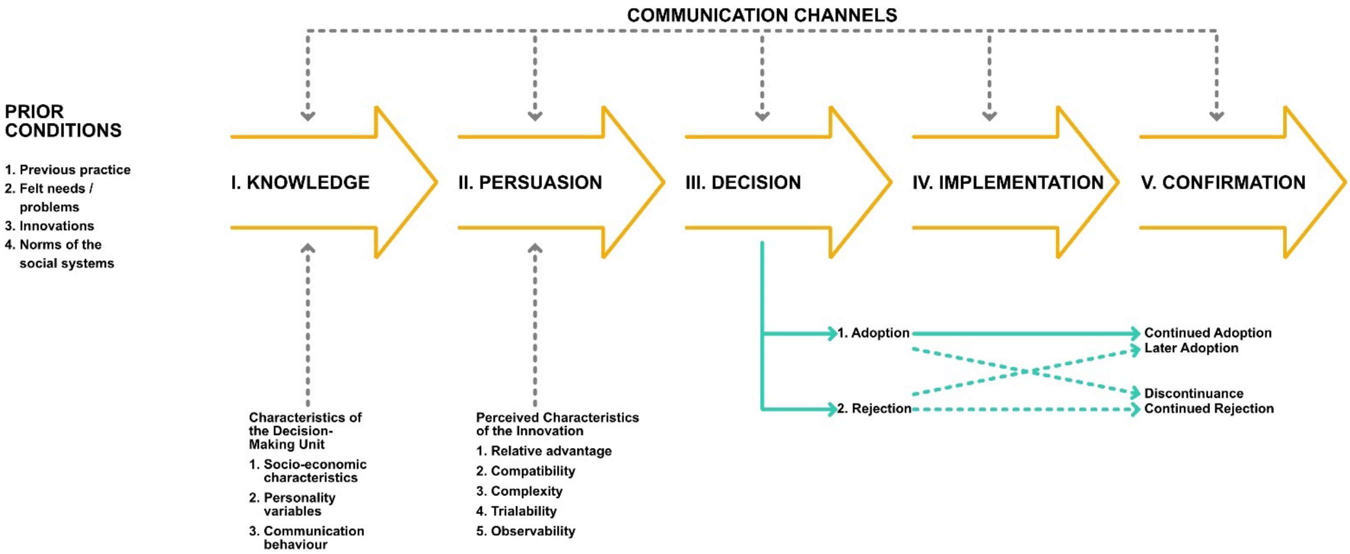


Figure 3.3 Five stages of technology adoption, Everett M. Rogers, 2003 *(redrawn by author)– Only once each of these stages has been successfully achieved is a technology adopted.*

Stage one - Knowledge, this is when an individual first becomes aware of an innovation, this awareness is influenced by individual characteristics.

Stage two - Persuasion, this is when an individual has enough information regarding an innovation's characteristics to make a personal judgement, favourable or unfavourable.

Stage three - Decision, has an individual chosen to adopt or reject the innovation.

Stage four - Implementation, this is when an individual, acts upon their decision.

Stage five - Confirmation, when an individual reflects on their decision and re-evaluates whether to continue or abandon their adoption of the innovation (Rogers, 2003: p.20).

3.3.3 Critical Lens 3 - The Four Components of Diffusion

Rogers then goes on to set out the four primary components of diffusion theory, these are:

a) The **Innovation** itself. Rogers identified five separate attributes that influence an innovations adoption: relative advantage, compatibility, complexity, trialability and observability.

   i) Relative advantage is the perception of an individual that the innovation will be better or worse than similar ideas, those which are perceived to be better will be adopted more quickly.

   ii) Compatibility is the perception of how congruent with existing understandings of similar and past ideas the innovation is.

   iii) Complexity refers to how difficult to comprehend an innovation is perceived to be.

   iv) Trialability relates to the accessibility of the innovation to an individual.

   v) Observability is characterised by how visible and available an innovation is to an individual.

b) **Communication Channels** are the means by which information concerning a particular innovation is passed from one individual to another, this can include direct communication, observations of peers and mass media. This communication process is essential for the diffusion of a technology.

c) **Social system**, in IDT this refers to the context, culture and environment that an individual is involved in, social norms and structure influence and affect how an innovation infiltrates a population.

d) **Time** – Rogers frames his work through the context of time, he categorises adopters into groups based on the relative duration of time it took for a percentage of individuals to adopt [Fig. 3.4].

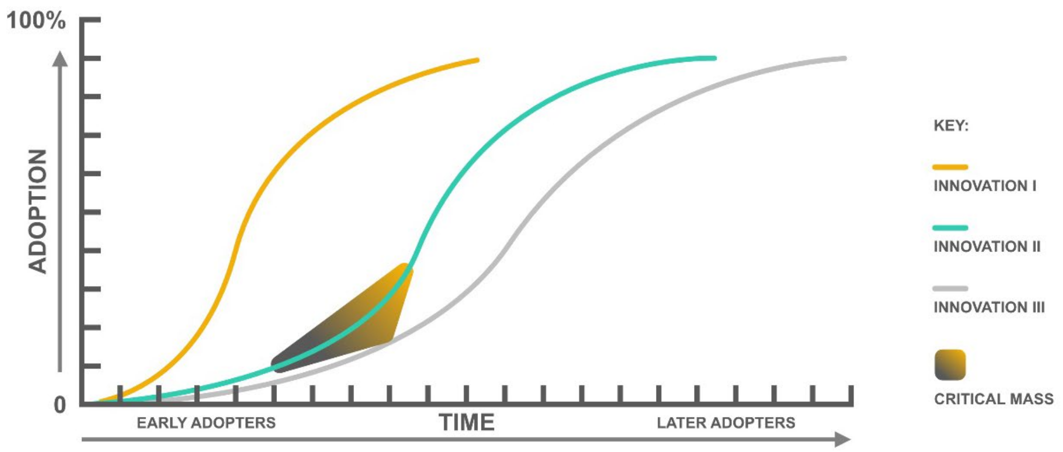


Figure 3.4 Diffusion of an Innovation diagram, Everett M. Rogers, 2003 *(redrawn by author) –The diffusion process differs from one innovation to the next, Rogers frames this using time. Each innovation begins with a small number of early adopters, the anticipation being that this number will increase until it reaches a point of critical mass, once this occurs the successful adoption of technology should be assured. By this stage, each of the four factors have exerted their influence and the late adopters have been able to observe the success or failure of the technology by learning from early adopters.*

Whilst IDT provides a strong framework, it is primarily descriptive and as such does not tell us how to facilitate adoption, but rather why adoption occurs. As has been evidenced, there are many different factors within adoption diffusion theories that influence whether an individual will choose to adopt an innovation, and these factors constantly interact to inhibit and/or promote change (Adler and Clark, 2008). Understanding or controlling any one of these factors does not guarantee success, even if the innovation is the most useful/appropriate, as contextual factors also contribute to non-adoption (Rogers, 2003). Personal factors, characteristics of innovation and an individual's context all shapes their decision and the degree to which they will persist with an innovation, as such technology adoption is innately social, with individuals influenced by peers, change agents, organisational pressure and societal norms (ibid.).

3.3.4 Critical Lens 4 - Theory of Planned Behaviour

Technology adoption and diffusion can be further explored through Ajzen's *Theory of Planned Behaviour* (Ajzen, 1985), which has previously been applied by organisational psychologists to study the adoption of new technologies (Venkatesh and Morris, 2000). The *Theory of Planned Behaviour* defines the relationship between attitudes, norms, and control as determinants of intention and behaviour, the key determinants of this are defined as follows:

1. *Attitude toward behaviour* “refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question” (Ajzen, 1991: p.188). In a technology adoption context, the key behaviour of interest is the use of a new technology. This can be described as a potential user’s affective evaluation of the costs and benefits of using the new technology (Venkatesh and Morris, 2000).
2. *Subjective norm* “refers to the perceived social pressure to perform or not to perform the behaviour” (Ajzen, 1991: p.188). In a technology adoption context, this manifests as peer influence and superior influence (Venkatesh and Morris, 2000).
3. *Perceived Behavioural Control* is defined as “people’s perception of the ease or difficulty of performing the behaviour of interest” (Ajzen, 1991: p.183). In a technology adoption context, this refers to the perceived ease or difficulty of using a new technology (Venkatesh and Morris, 2000).

Individuals develop opinions about technology based on a number of individual factors, these include “prior experience, beliefs about specific and general abilities, stable personality traits, and mandated versus voluntary uses of technology. These beliefs are malleable” (Straub, 2009: p.641). As such, it has been suggested that structured educational experiences, personal experimentation, and social pressures and/or ‘change agents’ are possible moderators for attitudes towards innovations/technology (Agarwal and Prasad, 1998; Straub, 2009). Therefore, the success of technology diffusing into society is much more reliant on the attitudes and perceptions of society, rather than the actual design and functionality of the technology in question.

3.3.5 Summary

These critical lenses help in the process of rationalising and interpreting the findings from the data gathering sessions, by providing a theoretical framework for understanding what these responses mean to the adoption and diffusion of 3D printing technology. These theories reveal how 3D printing technology is currently viewed and the attitudes that people have towards it. These STS theories also perform an important role in the process of backcasting, which will be discussed in greater detail later in this chapter.

3.4 Futures Studies

There already exist a plethora of established typologies for futures scenarios, which are important tools for developing methods for futures studies (Börjeson *et al.*, 2006). Whilst *futures* studies have already been the focus of discussion in Chapter Two, the focus then was on providing an understanding of the *what,* whereas the focus now is in explaining the *how* and *why* this research intends to use futures studies.

3.4.1 Design Fiction

Design has a long tradition of using objects, models and prototypes to engage users and clients to test out and inform new ideas, and there is an increasing range of research tools being developed and adopted to facilitate interactive and participatory design (Chamberlain and Craig, 2013). One such design tool which is of particular interest to the design research community (Hales, 2013) is design fiction, an offshoot of speculative design. Whilst the term speculative design might conjure up visions of jet packs and flying vehicles, or any number of classic 'visions of the future', it does however follow the rules of real life and is based on logical projections of emerging technology, as shown in [Fig. 3.5]. The success of a speculative design project rests on the ability of an audience to relate to the proposal, therefore it is necessary to bridge between the existing world as perceived by the audience and the fictional elements of the concept (Auger, 2013).

The term design fiction is attributed to the Science Fiction and Cyberpunk author, and design theorist Bruce Sterling, who when questioned on the impact that design has had on his writing stated that although design fiction is more practical than science fiction it "reads a great deal like science fiction; in fact it would never occur to a normal reader to separate the two" (Sterling, 2005: p.15). His description of the term design fiction was further refined following a collaboration with Bleecker and The Near Future Lab, when Sterling stated "*Design fiction* is the deliberate use of diegetic prototypes to suspend disbelief about change" (Shedroff and Noessel, 2012: p.xx).

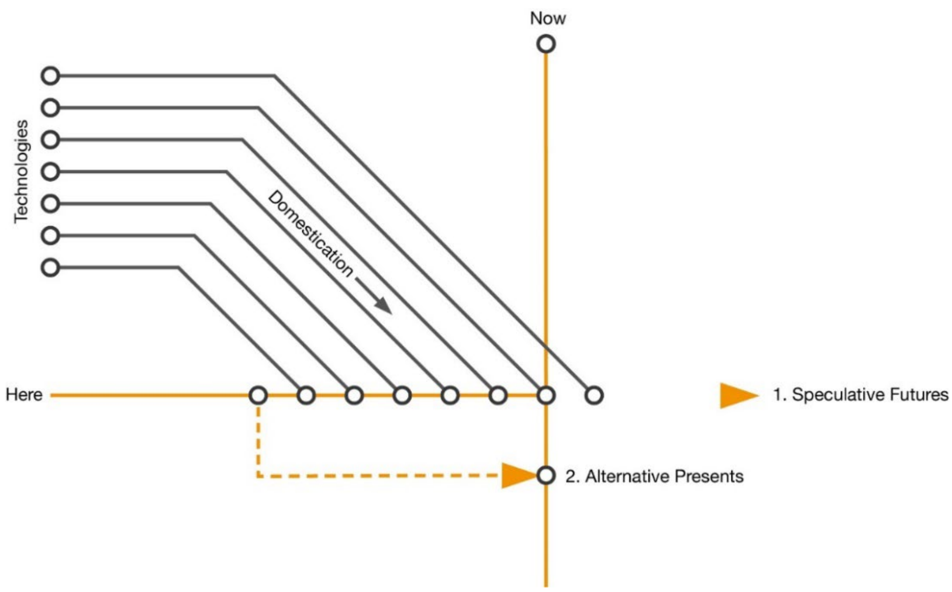


Figure 3.5 Speculative design methodology diagram, James Auger, 2013 *(redrawn by author) – The technology element on the left represents emerging technology, the higher up the more emergent the technology and therefore its route to being adopted into everyday life is longer and less predictable. Speculative designs exist as projections of this lineage, in that they are extrapolated developments of an imagined emerging technology. By stepping outside of the boundaries of our current reality, these designs are free to challenge existing manufacturing, cultural and political systems.*

Sterling has since expanded upon this statement, explaining that by *deliberate use* he means that it is "not a form of design that is accidentally speculative or critical; it is deliberately so". Diegetic prototypes are intentionally provocative, aiming to elicit some futuristic engagement or enthusiasm.

Sterling explains that the reaction to seeing a diegetic prototype should not be “Oh, what’s that? Can I buy it?” but “Wow” or “What a difference that would make” (2017). This relates to the important term that follows, *suspension of disbelief*, which is a practice not restricted to traditional literary methods, but instead is about making use of a much broader tool set to suspend disbelief in a user, viewer or participant. Finally, there is the term *change*, for which Sterling makes the point that he “make[s] no claim that this *change* is inherently good or bad, positive or negative… *Fiction* can arise from any number of ideological and moral standpoints” (2017: p.18).

Another explanation of design fiction has been provided by Science Fiction author Cory Doctorow (2016) who described how an engineer might make a prototype to give you a sense of how something works; an architect will do a fly-through to give you a sense of its spatial properties; fiction writers produce design fiction to give you a sense of how a technology might feel. Design fiction offers designers the opportunity to explore and critique possible futures and the technologies they embrace. Bleecker (2009) states that design fictions are about creative provocations, asking questions, innovating, and exploring new kinds of social interaction rituals. As such design fiction is a useful tool to envision new technologies in the future, accompanied by a narrative to show how these technologies are positioned within this new context (Tanenbaum, 2014b).

Design fiction resonates with the audience because “so-called possible world theory is based on the assumption that fictions can be properly understood as *possible worlds*, which can be either easy or difficult to access from our real world” (Markussen and Knutz, 2013: p.233). While the audience may be able to *suspend their disbelief* by recognising the work as a fiction, the accompanying technology or artefacts must contain a certain logic if it is to be believed. Tanenbaum describes this as “[o]bjects and technologies that exist within the fictional world must abide by the rules of that world. Even if we don’t fully understand those rules, they still must be seen to exist and to operate with consistency” (2014b: p.22). Therefore, the questioning of the scenario by various audiences is crucial to the success of *speculative design*, resulting in a collective decision on what the preferable futures are for the given group.

Novelist Umberto Eco once described how fiction performs the same function as games, explaining that "…whilst playing, children learn to live, because they simulate situations in which they may find themselves as adults, and it is through fiction that we adults train our ability to structure our past and present experiences" (2016: p.8). Bleecker has shared a similar sentiment, stating:

> Making things up is playful and serious at the same time. It's playful in that one can speculate and imagine without the "yeah, but…" constraints that often come from the dour sensitivities of way-too-grown-up pragmatists. It's serious because the ideas that are "made up" as little designed fictions – formed into props or little films or speculative objects – are materialised things that hold within them the story of the world they inhabit (2017: p.27).

Design fiction provides this 'play space', it is a methodological tool that enables designers to envision new technologies for the future and using narratives show how these technologies would be positioned within a new context; it is a technique for reflecting on what technology we should, or should not, design (Bosch and Sterling, 2012; Tanenbaum *et al.*, 2013). Emerging technology is often the focus of design fiction as during this early phase the technology is still in flux and has not quite crystalized (Dunne, Raby, et al., 2016). This enables designers to explore the different possible manifestations of a technology before they have become adopted by society, as once it enters into our everyday lives new "behaviours and conventions begin to emerge and solidify" (Dunne, Raby, et al., 2016: p.58)

When *speculative design* is used in relation to futures studies it is important to consider that the outcome will always involve a proposed change for the better, but better can mean different things to different people. Therefore, the questioning of the scenario by various audiences is crucial to the success of speculative design, resulting in a collective decision on what the preferable futures are for the given group. Designers should not be the ones defining futures for everyone, instead they should be collaborating with scientists and engineers to give them the freedom of imagination to create futures that promote public debate and discussions around the kind of futures that people really want (Dunne and Raby, 2013).

3.4.2 Mundane Futures

Whilst there is growing interest in the use of design fiction as a design method, it has also attracted a number of criticisms. When discussing his work with the *Near Future Laboratory*, Nick Foster describes the process of how they approach designing the future. The future is separated into two categories; *Now*, which includes everything that is being made now, and *Next*, which is everything that is in the pipeline or coming soon. Yet whilst there are established and reliable processes for *Now* and *Next,* when it comes to designing *the Future*, designers often find themselves stumbling between “tech digest and science fiction cinema” (Foster, 2015: at 03:05). Foster goes on to explain that often, future concepts seem like folly, merely indulgent fantasies that do not belong to a narrative and only reflect an isolated aesthetic, they present a “landscape that is devoid of relevance and any kind of association with [or] to anything else. They aren’t conversations, they are just statements. They are fantasies decoupled from reality” (ibid.).

As an alternative to this method Foster proposes *The Future Mundane*, which he describes as a design mindset comprised of three key points. These points in summary are:

1. The Future Mundane is filled with background talent, everyone in a future scenario is a user and you are one of them. We shouldn’t only be concerned with designing for the *lead actors* in our future scenarios, the supporting cast and crew are far more exciting.
2. The Future Mundane is an accretive space. Humans are covetous and sentimental, and we like to re-use and re-appropriate things, anything we create will inhabit the existing world.

3. The Future Mundane is a little bit broken, "…predict not the automobile, but the traffic jam" - Frederick Pohl. We can't hope to make the world or things better, if we ignore the fact that everything isn't going to be perfect.

If we are to propose useful visions for the future, we must accept that it is not just things that break, but also ideas. As designers we must become comfortable with the idea that no matter how well-crafted our message or story is, and no matter the intended use of the product, "things will be misinterpreted, misunderstood, misused, it will be broken and rejigged, and actually that's a good thing" (Foster, 2015: at 26:35). Whilst *science fiction* provides designers with a great place to start their enquiry, it must lead to a real-world proposal, and this requires much more rigour.

Whilst *design fiction* and *speculative design* methods have typically been used to create various speculative prototypes, these are primarily artistic artefacts intended as provocations. In the instance of this research however, the graphic social futures are not intended to be 'showy' or futuristic in the sense that diegetic prototypes are, as it is considered that this is unlikely to aid in understanding what the possible *social futures* of 3D Printing technology are. Instead, the speculative visions that result from this research are borrowing ideas from the *Future Mundane* approach, to represent an eve*ryday future '*for its cast and crew'*.* This is research into social futures, and in particular how the midwifing of these futures can occur by providing people with visual information that allows them to respond and describe the less spectacular ways in which the future might unfurl. The visual speculations will act as shared visions, providing a focus for debate in order to evaluate their suitability for the daily routines and values of users and their environments (Berker, 2006).

Traditional visioning typically involves the creation of a graphic vision, representing the values of a single corporation, which is used to provoke excitement and stimulate future demand for their products or services. The shared visions created by this process however are graphic visions that are representative of, and informed by discussions with people, to illustrate the more mundane futures that they perceive. As this research will show, using these more grounded visions as a platform for discourse is an effective method for revealing peoples hopes and concerns regarding futures. This could therefore be a suitable method for provoking discussions that influence policy (Voss *et al.*, 2015a), inspire technology companies to innovate differently (Dunne and Raby, 2013), or simply for the general public to reconsider their expectations for the future.

3.4.3 A Bottom-Up Approach

Whilst there are examples of *speculative design* being used to explore the implications of emerging technology (Voss *et al.*, 2015b), these are carried out using a top-down approach. When using such an approach it is the stakeholder and or designer who has the authority to decide upon the speculations being presented, these are then shared with an audience to elicit a response, or evaluate the success of these images, in a one-way flow of information.

This research has developed a bottom-up approach to speculative design [Fig. 3.6], one in which the intended end users of the emerging technology in question are given the opportunity to engage in shaping and informing the speculative designs. The critical lenses have been introduced to provide a means of objectively analysing and interpreting the findings from each of the data gathering sessions. The ideas represented within each of the shared future visions is derived from the combined findings of the data gathering sessions, which are critically analysed using the critical lenses, with each of the data gathering sessions being discussed in its own chapter (Chapters Four, Five and Six). These critical lenses act as a filter of sorts, to understand what changes this technology could bring about and how they might manifest. This has been an important addition to the process, as this enables the designer to also make use of the more fantastical ideas that emerged from the discussions, which might otherwise have been discarded. There were many discussions that erred on the fantastical side of an imagined future of 3D Printing technology, filled with hoverboards and spaceships. Using the critical lenses enables an understanding of the broader ideas at play and provides a path to navigate away from the trap of alienating the audience by presenting ideas which they cannot relate to.

The resultant graphic social futures are then used as the focus of further interrogation as a means of evaluating this process, thereby resulting in a novel, generative and iterative approach to *design fiction*. These visual speculations are an attempt to fulfil the unmet needs and desires of people (Celi and Formia, 2017), improving public involvement and empowering participants within the design process of emerging technology. This provides insight into how this technology could manifest in and contribute towards a social future.

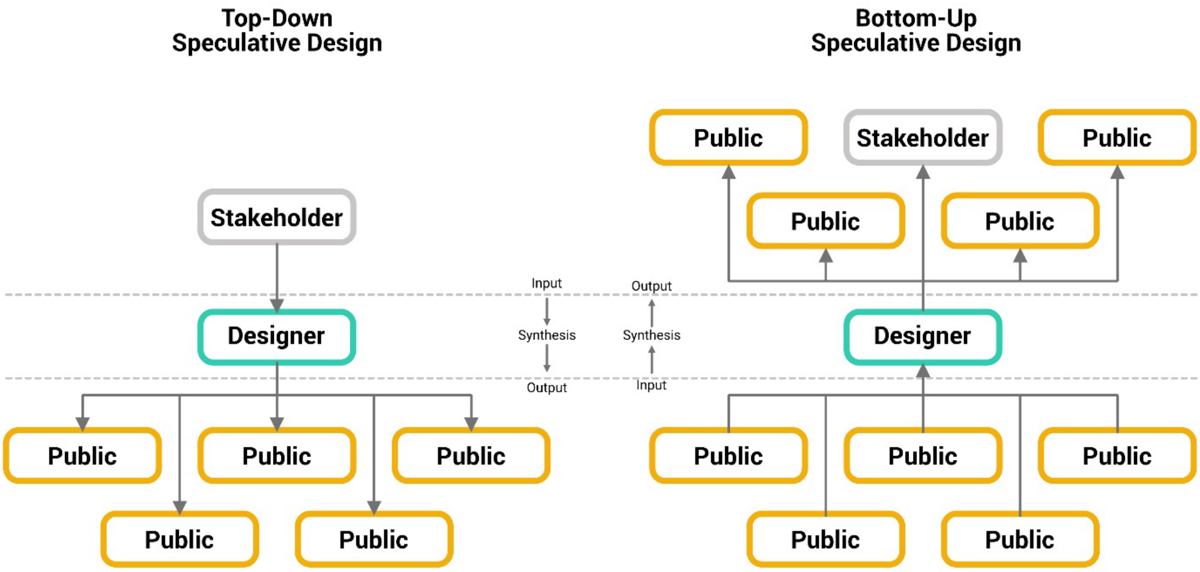


Figure 3.6 A Bottom-Up approach to Speculative Design – As has been discussed and shown in Chapter Two, typically when speculative design has been applied in the real world it is produced using a Top-Down approach, this research develops a Bottom-Up approach, positioning the public as active participants in the process, rather than passive viewers. This diagram of the methodology has been greatly simplified to indicate the primary actors only, not the processes that have taken place within. By placing the public at the beginning of the process they are much better positioned to actively engage with the research and contribute to an understanding of what is preferable for a more social future, rather than merely being an audience to the results at the close of the process.

The creation and presentation of these speculative future visions to the public (users) allows not only testing of the effectiveness of this process, but also further engages with the intended end users of this technology. This final layer of engagement enables further discourse around the findings of this research in understanding how emerging technology can contribute to the creation of social *futures*. This method therefore represents a practical bottom-up approach to design fiction in the real world.

3.4.4 Backcasting

A final and critical part for producing graphic social futures is backcasting. Backcasting as an approach to futures studies, in the context of this research, is designed to help people better understand future possibilities for personal 3D printing, for them to make better decisions today, in much the same way that one of the core purposes of futures studies is to promote a better understanding of alternative future opportunities. Whilst there is no consensus on a single classification of futures studies or a guide for the application of the most suitable approaches to futures studies, backcasting provides the most suitable methodological framework as this approach is prescriptive (normative).

Backcasting is closely related to both *visioning* and *scenario planning,* which Bibri (2018: p.10) describes as follows:

> **Visioning** is the action of developing, or the process of intensely making images of, the desired future (plans, goals, objectives, outcomes, etc.) sufficiently real and compelling to act as a stimulus or spur to the present action.
>
> **Scenarios** are about making stories about the future; they represent a series of events that we envision or imagine happening in the future. Visionary scenarios are part of everyday thinking in that it is filled with some ventures into the unknown or mysterious world of the future, tomorrow, next week, next year, or next decade.

Where backcasting differs is in the idea of taking a range of possible futures as a starting point, before assessing their potential and feasibility, and then considering possible ways of achieving those futures. Backcasting is concerned with *how* desirable and preferable futures can be attained, as opposed to simply *what futures* might occur. Liveley(2021, p.225) further explains backcasting as a process which "identifies a desired future telos and then extrapolates backwards to identify the chain of actions and events necessary to realise a temporal-causal sequence of events that will link that desired future to the present…". To achieve this, a desirable endpoint is identified, which in the context of this research is those futures as described by the participants, and then a series of backwards steps are taken to determine what actions or developments would need to occur in order to achieve the specified future. This is where the similarities to scenario planning are particularly apparent, as this can involve the construction of a plausible causal chain leading from 'here' to 'there', as shown in figure 3.7. This imaginary scenario can move backwards in time in as many stages as is necessary to uncover the mechanism by which the preferred future can be achieved (Robinson, 1990).

Much like there is no singular approach to future research, there are several *backcasting* approaches and methodologies. Whilst each of these approaches differs to some degree, Hojer & Wangel (2014) laid out the four fundamental stages that each backcasting approach involves. These are:

1. The setting of a few long-term targets
2. The evaluation of each target against the current situation, prevailing trends, and expected developments
3. The generation of images of the future that fulfil the targets
4. The analysis of images of the future in terms of feasibility, potential, and path towards images of the future.

If we apply these stages to this research, stage one refers to the findings of each the three data gathering sessions (wide information gathering), with stage two being the careful analysis and critical interpretation of these findings. Stage three refers to the curation and development of graphic social futures and stage four is the analysis and appraisal of these visions as uncovered in the final data gathering session.

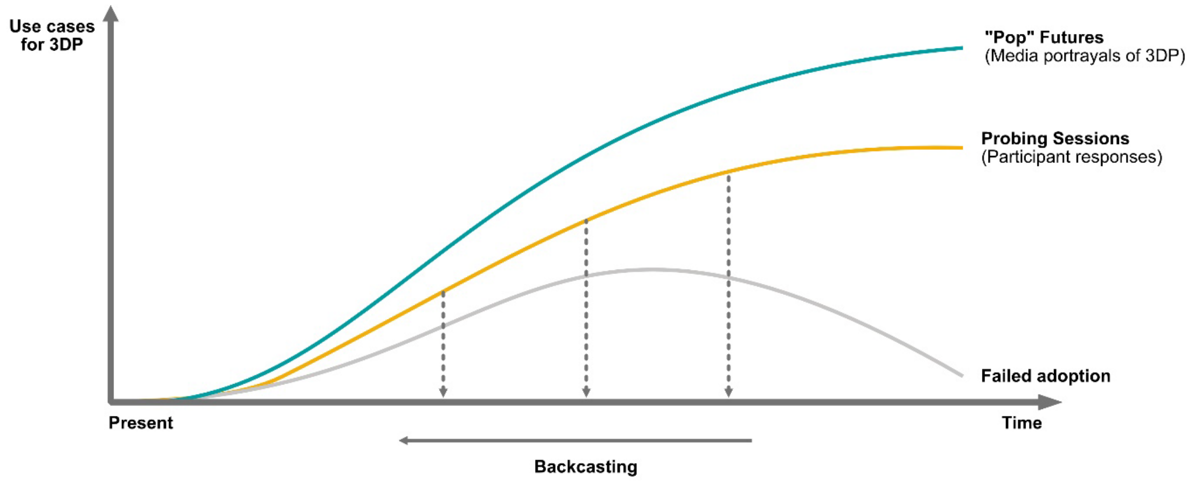


Figure 3.7 Diagram explaining the method of Backcasting – This diagram depicts the process of backcasting as applied to this research. The participant responses, once analysed and interpreted, provide the long-term projected futures for 3D printing. Working backwards from this endpoint, the necessary steps to ensure this 'successful outcome' are considered, e.g. What actions must we take to get there? This back stepping has been used to move the focus from a distant future where 3D printing is well established and part of our everyday lives, to a more near future, to explore what these interim scenarios could look like. These graphic social near futures provide the framework to aid in conversations with the public concerning futures.

3.4.5 Entry Points into Speculative Worlds

Design fiction makes use of diegetic prototypes as entry points into the speculative worlds that these artefacts exist within. These are interpretive and can encourage the viewer to consider and question the speculative world that could exist around these artefacts. The approach that this research is developing makes use of multiple entry points within each scenario that is presented, which is intended to provide more opportunities for the viewer to engage with the speculative world on a deeper level.

This research refers to these entry points as visual hooks, as they are small visual clues that will be littered throughout the illustrated scenarios. The visual hooks hidden within the graphic social futures represent clues as to the imagined futures revealed and described by the data gathering sessions. For the audience of the illustrations these visual hooks can operate in one of two ways; for those who recognise them as meaningful they act as visual prompts to help the viewer to construct their own world and develop their own narrative around how they could see themselves living in this alternative future, for others they will simply appear as part of the scenarios backdrop. It is not necessary for every visual hook to resonate with every participant, they are merely intended as a scaffolding to support a discussion and encourage the viewer when considering this future.

It is important to note that these visual hooks are not intended or expected to be the focus of the resultant discussions and findings, their role is to provide provoke and elicit responses from the participants, by providing some indication of change in the future for them to react to. It is in this way that they allow the viewer to construct their own world around them, using them as props in the personal scenarios that they create. The significance of each individual visual hook is therefore highly dependent on the individual viewing them, whilst they provide an entry point into these speculative worlds, it is down to the individual which, if any, they choose to make use of.

3.5 Socially Constructing Graphic Social Futures

One of the key mechanisms that make these speculative scenarios representative of social futures is the fact that they are socially constructed. Put simply, this means that the scenarios are a response to the thoughts, anticipations and expectations of the public who have engaged with this research, rather than representative of corporate interests. Pólvora and Nasciemento describe a similar approach as “set apart from creativity-only driven methodological affiliations” and is instead “tied to the evidence amassed through the projects research streams” (2021: p.7). This research follows this approach as an interpretation of one of the goals for social futures, which is to give a voice to past, present, and future societies. By involving the people who this research is intended to engage with from the earliest stages, their collective voice becomes the main input for describing alternative imaginaries, as shown in figure 3.8. The data gathering sessions use 3D printing as a driver for change, a catalyst to help the public consider *futures*, with the findings providing the material for world building of social futures.

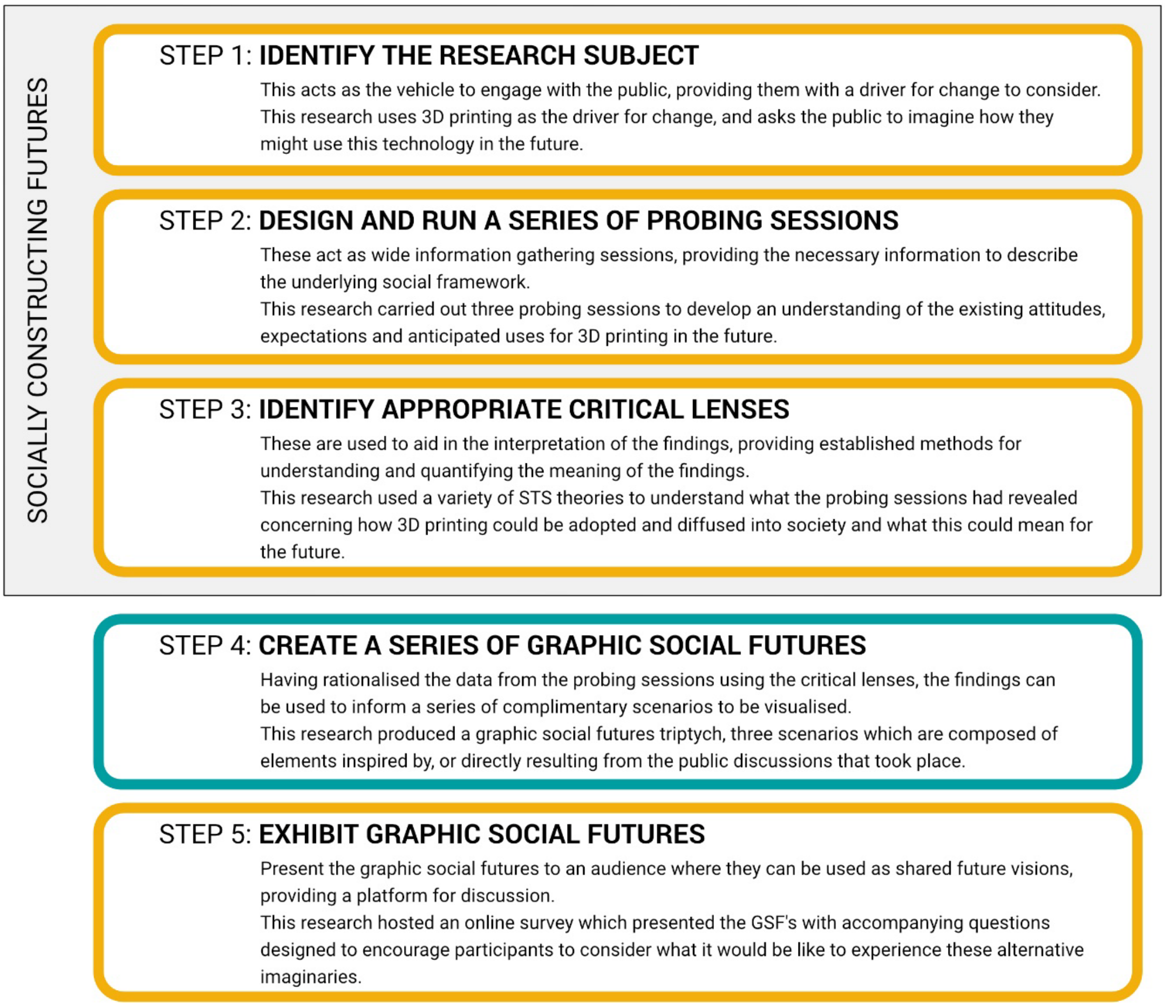


Figure 3.8 Process for socially constructed graphic social futures – This diagram provides an overview of the process that this research has developed for the creation of Socially Constructed Graphic Social Futures.

Applying the findings from the data gathering sessions to a series of appropriate critical lenses, provides a means of rationalising and critically interpreting the findings. Used in this way, it has the effect of reducing the designer's bias (conscious or unconscious) on the futures being presented, as the content and detail has been provided by the public. This allows for the creation of near futures which are rational and relatable but noticeably different, to elicit and provoke public discourse around futures. These five steps describe a generative design process, which uses a driver for change to facilitate the creation of alternative social imaginaries.

3.5.1 Depth and Resolution in Futures

The different approaches to the creation of future visions that have been discussed here share many similarities, where they differ, however, is in their intent. Futurists use visioning as a method to not only forecast, but also to encourage potential futures (Dunn and Cureton, 2020b). Though as previously evidenced, these can be entangled with corporate agendas or represent the proffered future as decided by a single organisation. Whilst Civilisational Foresight has been noted for its potential to explore foresight at the social level, it is currently the least common application for foresight (Voros, 2022). Design fiction then, provides a method for questioning *what* the preferred futures are that we should be encouraging. Being that design fiction as world building can be explorative and lack an agenda or vested interest, it is perhaps unsurprising that “design fiction is predominately practiced in academia and by grant-supported private practices: public money is almost always what pays for Design Fiction” (Coulton and Lindley, 2017: p.6).

The diagram below [Fig. 3.9] has been created to provide a visual representation of how this research positions each of these design approaches within the context of futures research. The two axes represent the *depth* of futures thinking as described by Slaughter(1989, 2021), and what is here referred to as the *resolution* of the world being presented. To understand this in relation to this research, the depth of futures thinking can be considered the extent to which the audience is required to participate in the vision and the *resolution* refers to how fully considered or complete the world being presented is.

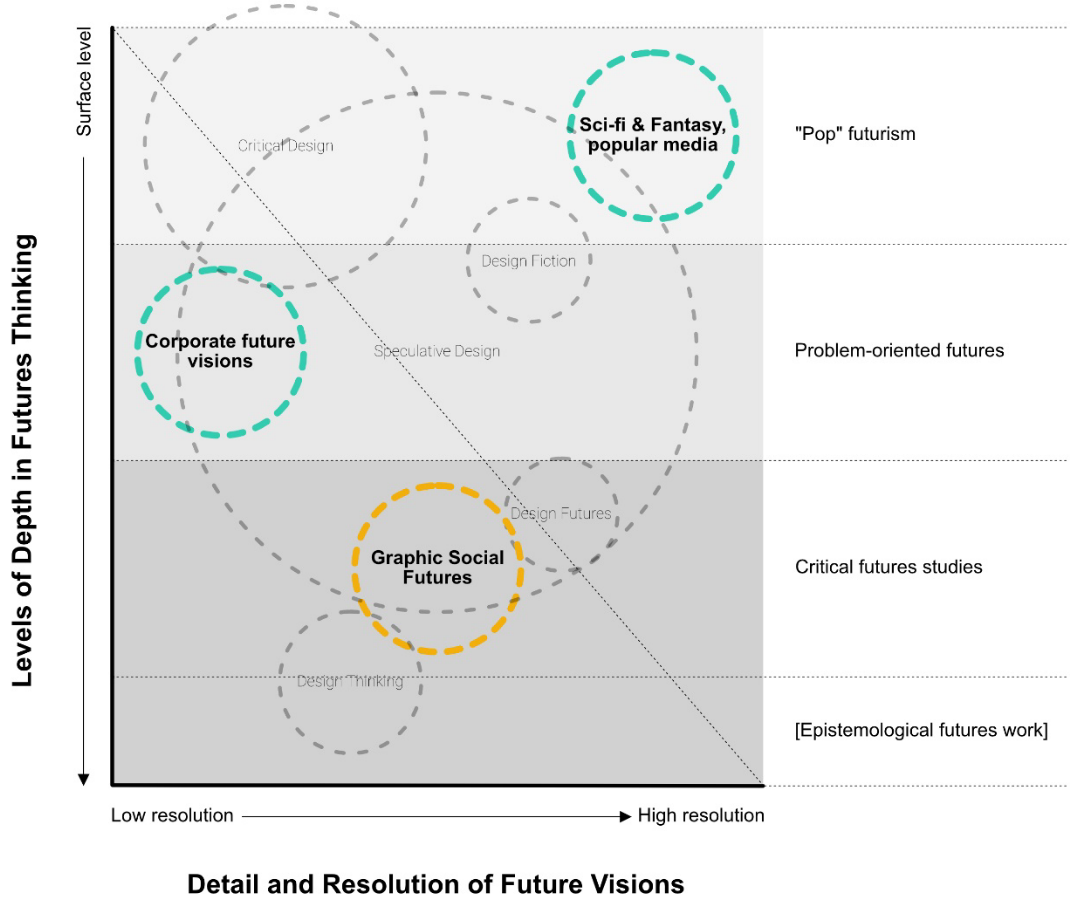


Figure 3.9 Diagram exploring the levels of depths in futures thinking and the resolution of future visions – This diagram situates the different levels of depth in futures thinking, as described by Slaughter (1989, 1999, 2002a)*, charted against the degree of resolution of a future vision. The deeper the level, the greater the requirement of engagement from the audience/viewer, which has an impact on the appropriate resolution for each type of futures vision. Mapped onto this is Montgomery's Unresolved Mapping of Speculative Design diagram* (2018)*, showing the relationships/overlaps between speculative design and related approaches.*

Slaughter defines the shallowest and most superficial level as *"Pop"* futurism, which is usually highly media oriented and is found in most television shows, films, articles and popular books when dealing with the *future*. *Futures* which fall into the category of "Pop" futures, present highly resolved and fully formed worlds, which can be highly engaging and extremely situated; however, the audience is only required to participate in the building of the world in a very limited way, as any entry points are shallow, because much of the detail has already been provided. A commonly used example of this is the film Minority Report (Spielberg, 2002; Doctorow, 2009) [Fig. 3.12], where much of the detail has already been provided and is highly rendered through the *mise-en-scène* and detail in production design. The audience is given glimpses into this future reality, but they are extremely restricted in considering the wider implications of this future due to it being a highly curated, fully framed and prescribed path through this future.

In the next layer down, we find what Slaughter (1989, 2002) refers to as problem-oriented futures, such as visions for future cities and corporate futures, an example for which is shown in figure 3.10 below. These visions which sit at the opposite end of the resolutions scale are often tackling *big picture* problems and are concerned with "how organisations and society might, or ought to, respond to challenges" (Voros, 2022: para.19). As such, these futures require a greater level of engagement from the audience as the visions are intended to alter behaviours or highlight issues. The scale and scope of these visions though means that they are often less situated and therefore less specific, i.e., they lack resolution when compared to "pop" futures. This lack of specificity results in highly porous future visions, which enables the audience to imagine how this could work within their local context. These futures often lack detail and are for the most part acontextual to be relatable and accessible to a wider audience.

The next layer down is Problem-oriented futures which is more serious and attempts to look at deeper issues and their causes. Voros (2022) considers this to be where most public sector and corporate strategic thinking takes place, tackling the *big picture* problems, such as climate change etc., with most *futures* work taking place in this realm. The next level down is Critical Futures Studies, which attempts to understand the root causes of the problems being addressed in the previous layer and is concerned with how we create meaning in a social context.

Figure 3.10 A still taken from the motion picture Minority Report, Steven Spielberg, 2002 – An example of what Slaughter refers to as a "pop" future. This presents a highly detailed, fully resolved and lived in world, which is highly situated.

In the next resolution, a layer down, we find problem-oriented futures [Fig. 3.11], such as visions for future cities and corporate futures. These visions are often tackling *'big-picture'* problems and are concerned with *"how organisations and society might, or ought to, respond to challenges"* (Voros, 2022: para.19). It is in this layer that we find corporate visions and vapourworlds, and as such, these futures require a greater level of engagement from the audience, when compared to "pop" futures, as these visions are intended to alter behaviours or highlight issues. The scale of these visions though means that these are often less situated and therefore less specific, i.e., lack resolution when compared to "pop" futures. This lack of specificity is intentional, as this permits the audience to imagine how this could work within their own context, therefore these futures often lack detail and are for the most part acontextual, in order to be relatable and accessible to a wider audience.

Figure 3.11 A still taken from the Microsoft Future Vision film 2040, Microsoft, 2017 – An example of what Slaughter refers to as problem-oriented futures. This presents a scene which is, by comparison to figure.3.12, low resolution and is highly acontextual, being that it does not present a fully resolved world. These future visions are intended to be accessible to a wide audience and many cultures and require some element of world building by the viewer.

This research uses the lens of *social futures* as distinct from *technological futures*, to explore alternative futures and present alternative pathways for how these futures might unfurl, and as such sits within Critical Futures Studies [CFS]. Goode and Godhe (2017: p.108) explained that *CFS:*

> Investigates the scope and constraints within public culture for imagining and debating different potential futures. It interrogates imagined futures founded – often surreptitiously – upon values and assumptions from the past and present, as well as those representing a departure from current social trajectories.

Though CFS sits within *futures studies*, there are several qualities that make it distinct. Goode and Godhe describe these as:

1. CFS is heavily invested in cultural analysis.
2. CFS is heavily concerned with the ways in which certain *futurescapes* carry affective weight, and also with the ways in which they compete for legitimacy.

3. CFS openly declares its commitment to the democratisation of the future and its antipathy towards a technocratic ethos that claims the future is best left to the experts. (ibid.)

Critical Future Studies therefore require the greatest level of audience engagement (sitting at a deeper level of depth) as this is concerned with *"how we create meaning in a social context, …[and] what constitutes social life"* (Voros, 2022: para.20). In terms of resolution then, these futures must be sufficiently realised as to provide a rich experience for the audience, but must also be sufficiently porous, providing multiple entry points to effectively support the audience in further constructing their own imaginaries around them. Successfully achieving this balance is one of the key challenges to producing graphic social futures. This research aims to successfully achieve this by producing flexible framing devices, scaffolding like frameworks that present not futures as such, but provide a sketch outline of how the future could be. These are open ended and provisional, which enables the viewer to imbue their own meaning upon them, they are suggestions that people can use and interpret in their own myriad ways. This research is therefore also concerned with critical futures studies, which requires the greatest level of audience engagement (sitting at a deeper level of depth) as this is concerned with "how we create meaning in a social context, …[and] what constitutes social life" (ibid). Slaughter explains that critique is a central methodology, used for "probing beneath the surface (of social reality), or looking more deeply", and that a working definition for critical future studies (CFS) is the "attempt to generate new knowledge about the constitution of human futures" (Slaughter, 1998: p.9). It is for these reasons that CFS is considered a suitable approach for understanding the alternative futures that this research will be interrogating. Godhe and Goode (2018: p.152) describe CFS as "the exploration and interrogation of ways in which society thinks, imagines and talks about the future – not the future singular, but possible futures." They go on to explain that the focus of this analysis can be a broad range of things, including images and ideas about the future produced by different fields of science (including the social sciences) and futurology. In addition to this, Godhe and Goode also state that CFS takes seriously the role of popular culture, including popular science, science fiction and technology journalism, embracing futures that have been created outside of expert domains, as these can be popular discourses that reach the wider public. These are also considered important sources for adding rich details and depth to the graphic social futures that this research has produced. The speculative visions are themselves intended as tools to engage the public in CFS, providing them an opportunity to respond to the visions and critique these futures, revealing their anticipations, expectations, concerns, and fears.

3.5.2 Probing Beneath the Surface

The idea of layers within futures is also discussed by Levitas (2013a) who, when describing Utopia as method, explains that it is comprised of three modes. These are:

Archaeological Mode – which is concerned with understanding and opening up to critique, the images of a good society and its underpinning policies, politics and culture.

Ontological Mode – which is concerned with the sociological understanding of what capabilities are valued, encouraged, enabled, or blocked and suppressed by existing social arrangements.

Architectural Mode – which is the culturally most familiar mode and is concerned with imagining a reconstructed world and describing its social institutions.

This layered approach to understanding utopias and the different depths of understanding required to see the picture as a whole, resonates with the work of Slaughter, particularly when discussing the architectural metaphor, which was created by Mochelle (1986), to explain that it is not possible to "approach the great issues of our time without considering the frameworks of meaning and value which created them in the first place" (Slaughter, 1989). Levitas too describes how the three modes of utopias are not different methods, but three aspects of the same method. Whilst this method is subject to shifting emphases, much like Mochelle's architectural metaphor, it is necessary to understand the foundation (Archaeological mode) if the subsequent levels are to be successful.

The diagram below [Fig. 3.12] shows how these methods for understanding futures, discussed by Slaughter (1989), Mochelle (1986), and Levitas (2013a), can relate to one another. This adapted diagram of Mochelle's architectural metaphor also includes the approach to graphic social futures that this research has developed, indicating how this research can be understood in relation to them. This demonstrates the similarities in the way that futures are considered, understood and discussed. As Gaziulusoy and Ryan (2017) explained, it is not the visions themselves that are valuable assets of these processes, instead it is the conversations that occur when interrogating them. It is in this manner that this process for the social construction of graphic social futures will be shown to be successful.

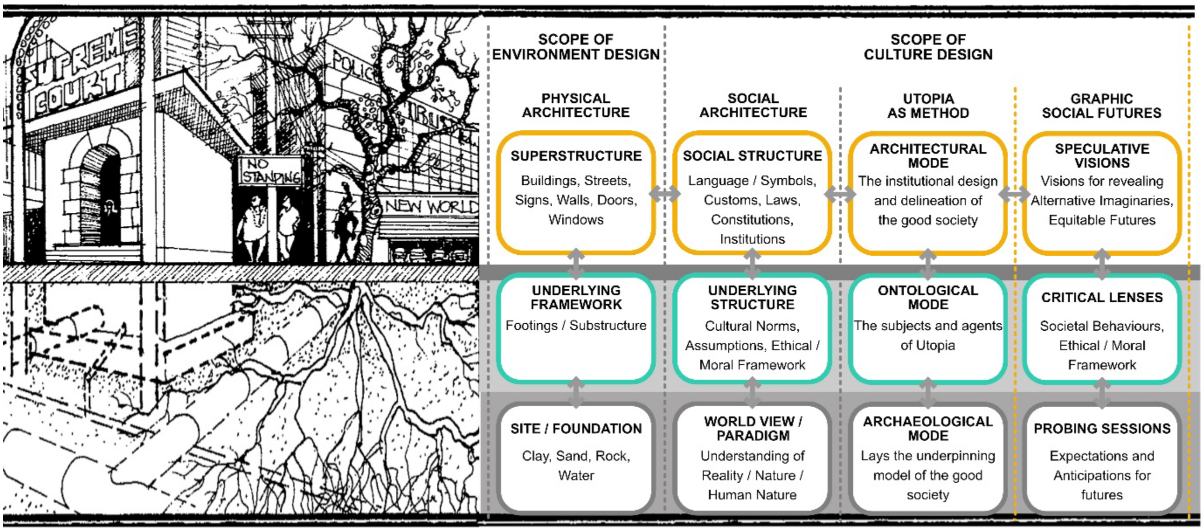


Figure 3.12 Modified version of Mochelle's diagram [Fig. 1.8], exploring different layers of futures thinking – Note: This diagram combines the work of Mochelle (1986) *Slaughter* (1989) *and Levitas* (2013) *and positions the methodology that this research has created alongside them, to better understand and illustrate how these different approaches relate.*

3.6 Conclusion

The intention throughout this research has been to position the public (as representative of the social) as the primary stakeholders and audience for the resultant graphic social futures. However, as the researcher is also the author of the future visions, there is a need to be transparent regarding the inherent unconscious bias that inevitably exists. Future visions promote certain ideas and values through what they include or, indeed, omit (consciously or unconsciously) and thus shape our intentions toward futures. It is for this reason that the idea of three distinct data gathering sessions (wide information gathering sessions which are the subject of Chapters Four, Five and Six) were introduced, as they also provide a process for the critical evaluation and consideration of the findings and subsequent interpretation of these data sets.

Science and Technology Studies was introduced as a means of quantifying the interpreted data, as opposed to merely relying on personal interpretations. These *STS* theories have provided the framework for the careful analysis and critical interpretation of the data collected throughout the data gathering sessions. This has been necessary in to develop an understanding of the process of how 3D printing could be adopted in the manner that the findings suggest, and what impact this could have on our future. This process was aided using data analysis software, *NVivo* and *Tableau*, which have uncovered trends and patterns that emerged across these data gathering sessions, which otherwise would have remained hidden.

The graphic social futures that result from this combination of approaches are representative of a grounded, lived-in world, with every included detail being justifiable (as will be discussed at length in Chapter Seven). These graphic social futures are then used as a platform for a final data gathering session (discussed in Chapter Eight) and a series of follow up discussions (discussed in Chapter Nine) as a means of evaluating the effectiveness of these visions as a tool to aid in the conversations with the public concerning *futures*.

This research proposes a methodology for the construction of speculative visions that are created using user driven data, in efforts to address the criticism “what does preferable mean, for whom, and who decides” (Dunne and Raby, 2013: p.4). Using a social approach to design fiction, future visions can present curated, preferred futures, which are informed by the public, therefore reducing the impact of the designer’s unconscious bias on the visions. By engaging with the public at every stage of the process, not only can their voices inform the resultant visions, but they are also able to interrogate and explore them. What follows is the development of this approach to generate socially constructed imaginaries, to better facilitate discussions around the future of technology.

4.0 Data Gathering Session One: Workshop

4.1 Introduction

This chapter describes the first of the three data gathering sessions, designed to gather data relating to peoples current understanding of 3D printing technology. It begins with an explanation of the aims and scope of this data gathering session followed by an explanation of the process undertaken in designing the research activity. The context within which this data gathering session takes place plays an important role in the design and fabrication of the research activity, as such this is also discussed. The findings from this data gathering session are then described in two parts, the first covers anecdotal data that was collected from conversations with participants, with the second part describing the data itself and how this is understood using the critical lenses. Then follows a discussion on the lessons learnt from having carried out this initial this data gathering session, before concluding with an explanation of the main findings.

4.2 Planning a Data Gathering Session

The first step towards understanding the current tensions and social barriers affecting the adoption of 3D printing technology, was to establish a baseline of the expectations and anticipations that the public held for this technology. Through personal experiences and discussions with the public who frequent the local makerspace, there was already some knowledge of what people expect from this technology. However, this knowledge is somewhat limited in its sample size and represents the views only of those who have decided to engage to some degree with this technology by entering a makerspace in the first instance. Rather than bringing personal bias and assumptions into this research, it was necessary to collect data from beyond local makerspaces, which would be more representative of the wider public. This would allow the development of a baseline of the current anticipations and expectations that the public have for 3D printing technology. This was necessary to begin understanding what the current level of awareness for this technology was.

A local makerspace, The Making Rooms was invited to attend the Bluedot 2018 festival as an exhibitor, which would provide the opportunity to carry out this first stage of research. Whilst a summer festival may not appear the perfect context for researching the future of 3D printing technology, Bluedot is a music, science and culture festival. Over the course of the weekend, the Jodrell Bank Observatory grounds are filled with a diverse variety of science and technology experiments, exhibitions and talks, and so research concerning 3D printing would not seem out of place. It was decided that The Making Rooms would take a selection of digital fabrication equipment to create a mobile FabLab, allowing us to showcase the technology we have access to and promote the kind of projects that take place in our lab. The final setup included a laser cutter, two Ultimaker 2 3D printers, a 3D printed controllable robotic hand, and an optical theremin project. This exhibitor stand provided an appropriate context for this research and more importantly helped attract participants to this research activity.

4.2.1 Designing the research

This data collection had to be designed as an activity that would appropriately sit within The Making Rooms exhibition space and attract as many participants as possible over the course of the weekend. While there was no minimum requirement for the number of participants that this data gathering session had to secure, it was hoped that at least 50 people would complete the activity. It was also necessary to consider how to ensure that the information being collected would be useful for this research, e.g. could the results be compared and were they meaningful. Ideally the wide data gathering would occur through detailed conversations with each of the participants, providing the opportunity to ask a series of questions relating to each of the factors that form the critical lenses. However, whilst an intensive exercise might allow for a discussion of each of the factors that make up adoption theory, it was considered that this would prove to be overwhelming, additionally, due to the time this would take it would also somewhat limit the number of participants able to complete the activity.

As this was also the first experience of running a participation activity of this kind, there was also concern regarding how many people would be willing to engage with this research and how much time they would willingly devote to it. It was therefore felt necessary to strike a balance between the depth of enquiry and breadth of questioning. It was therefore decided to ask a short series of questions, the answers of which could then be analysed and critiqued, extrapolating the ideas discussed, revealing inferred information using the critical lenses as guidance.

Since this stage of research was about understanding the publics perceptions and understanding of the technology, Ajzen's *Theory of Planned Behaviour* (TPB) would be used to guide the questions. *TPB* defines the relationship between attitudes, norms and controls as determinates of intention and behaviour. Attitudes toward behaviour refers to interest in the use of a new technology, subjective norms refer to peer influence to use new technology and behavioural control refers to the perceived ease or difficulty in using a new technology. A series of questions was devised that would encourage a breadth of discussion, but also provide responses that correspond with TPB. These were;

1. What do you think your family would print?
2. What's the biggest thing you would print?
3. What's the most expensive thing you would print?
4. Where would you use a 3D Printer?
5. What materials would you like to print with?

The first question was intended as an ice breaker, as it can be difficult to get people to think beyond their own everyday experiences, it is easier to think how others would respond, as this already involves thinking beyond your own experiences. The subsequent questions provide further insights into what people expect 3D printing technology to be capable of. Their responses can also be used to indicate the anticipated scale, complexity and sophistication of the technology.

Accompanying these questions, four future scenarios were developed that participants would be asked to consider, before answering the same series of questions for each scenario. Scenarios are a way of speculating on how the future might unfold, these are not predictions, but plausible descriptions of what could happen. They are used in future studies as a tool to help participants open-up and encourage lateral thinking (Birtchnell and Urry, 2016). Using multiple future scenarios also helps steer the discussion away from the focus being about whether these are possible, plausible, probable or preferable futures, as this research is not an effort to predict or forecast the future. Each of the four scenarios developed were designed to be easily imaginable with a minimal explanation or description required. They were also designed to be highly polarising and contrasting scenarios, with the hope that this would help to elicit responses. The use of four future scenarios was influenced by the work of Birtchnell and Urry (2013) who developed four self-contained 'worlds' to explore people's engagement with 3D printing technology and the degree of its corporatisation. To do this they used the axis of uncertainty, whereby two uncertainties are put on opposing axes and then it is considered how these could be connected, as shown in figure 4.1 below.

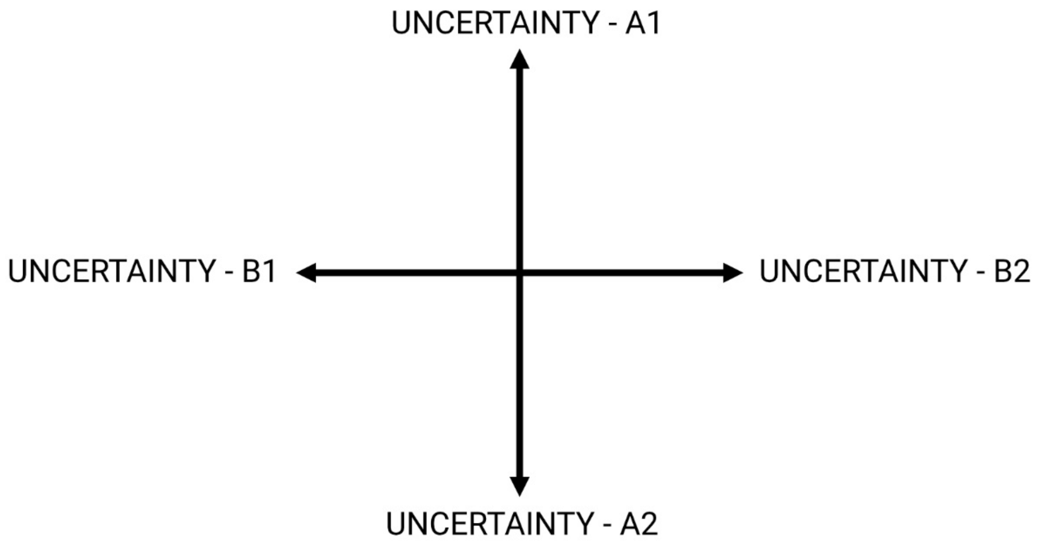


Figure 4.1 The axis of uncertainty diagram, whereby two uncertainties are placed on opposing axes and it is then considered how these could be connected.

The first axis related to the affordability of 3D printing technology, which represents the capacity for people to develop social practices around the technology as it becomes 'normal', which impacts a technologies adoption by society. The second axis represented who the main developer of this technology would be, for example, was it large corporations, or societal groups and individuals that dominate the development of this technology.

This research used the same axes to create its own series of self-contained 'worlds', these were:

1. **The Future**

   Business as usual, slow incremental improvements to 3D Printing technology.

2. **The Sustainable Future**

   A zero-carbon future where everything we make must be disassemble-able and reusable or fully recyclable.

3. **The Democratic Future**

   A future where cost effective 3D Printing technology has been made available to anybody and everybody.

4. **The Elitist Future**

   A future in which 3D Printing technology has become highly sophisticated and capable of producing anything but is accessible to only an elite few.

Scenario one *The Future* was intended as an easy way to introduce the use of scenarios as this scenario involved no major change to the status quo. Participants were simply asked to imagine how they would respond to the questions if they found themselves in this future scenario. The second scenario *The Sustainable Future* was used to discover to what extent they expected they would use 3D printing technology if the primary concern was sustainability. Whilst other terms, such as eco-effective, may be more appropriate to explain the ideals that this scenario presents, the word sustainable was used as it is more widely understood. This second scenario was intended as the polarising opposite of scenario one which represents consumerism. The third scenario *A Democratic Future* represents the ideals of the maker movement, a future in which 3D printing technology is accessible to everybody. This is not to say that everybody owns a 3D printing device, but access to the technology is open to anybody who wants it. The fourth and final scenario *The Elitist Future* is the polar opposite to scenario three, a future in which access to 3D printing technology is highly restricted. Each of these scenarios were created to see if and how the participants expectations and anticipated uses for 3D printing technology changed in relation to the different scenarios they were presented with.

4.2.2 Making the Activity

With the questions and scenarios finalised, the next step was to decide how best to format this research activity for the festival. In order to fit in with the Making Rooms exhibition it needed to be designed as an interactive activity, rather than merely being a form filling exercise. It would also need to be something that would be visually engaging in order to encourage people to participate, hopefully drawing in visitors from other exhibitors. The activity was given the title *3D Printing the Future?* as this indicates what the research is about and is also quite provocative. As there were four scenarios, a large board could be split into quadrants, which would allow for one quadrant representing one scenario, and would create a suitable display, as shown in figure 4:1.

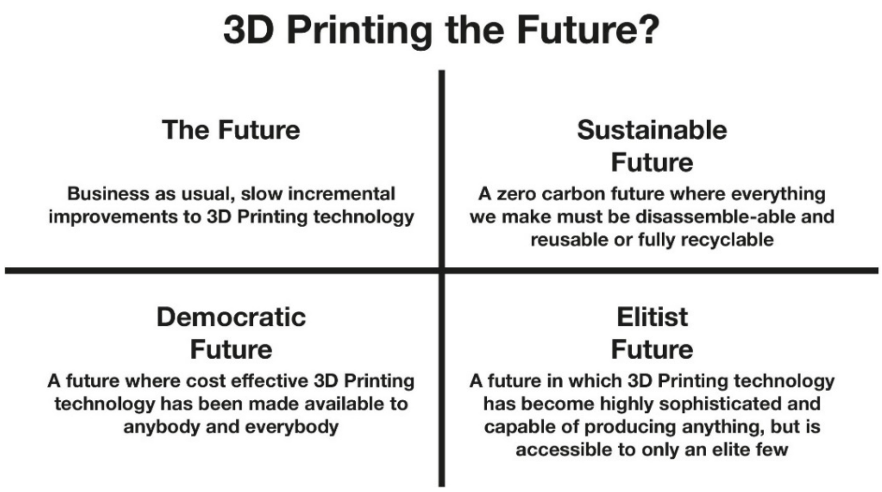


Figure 4.1 Research board design for data gathering session one – The response board for this research activity was split into quadrants, one for each of the four future scenarios. The response board when fabricated would provide ample room for participants to 'post' their responses onto the corresponding quadrant.

This data gathering session now needed a way for participants to record their responses to the questions for each of these scenarios. The original idea was to hand out printed sheets which would be laid out in the same design as the response board, once completed these would be collected from each participant. However, this was not considered to be a very interactive way of doing things and having recently attended several research workshops, it was decided that instead, post-it notes would be provided for participants to record their responses. Experience suggested that the use of post-it notes have been very successful in encouraging people to get involve and start writing their ideas down, far more so than when faced with a white sheet of paper. This would also allow the participants to 'post' their responses directly onto the corresponding quadrant of the board, this would create a visual record of the research process, it was also hoped that this would help to attract other participants. The use of different colours would also aid in the post analysis process as grouping participants responses would be far more straight forward with a colour coding system. Each participant was therefore instructed to select one colour for their responses, they would then write down their responses to each question for each of the scenarios. Once completed they would have four post-it notes in total, each containing five answers, which could then be positioned on the appropriate quadrant of the board.

Prior to the Data Gathering Sessions being run, ethics approval had been sought from the University. Once a prospective participant approached the display, a brief explanation of the process was provided, if they confirmed they were interested in taking part a participant information form was provided to explain the process in more detail. Once they had read and understood the participant information form they were given the opportunity to ask for further clarification or explanation about anything they were unsure of. Each individual was then provided with a consent form to complete prior to taking part in the process.

4.4 The Festival Experience

Over the course of the weekend, the *Bluedot* festival of 2018 attracted over 18,000 visitors. Admittedly not all these visitors made it into the Mission Control exhibition tent, where we (the team of *The Making Rooms* volunteers and staff) were located, nonetheless we were extremely busy throughout the weekend, as evidenced in figure 4.2. Carrying out this data collection alongside live demonstrations of digital fabrication technology undoubtedly helped to attract people's attention and in total I was able to collect responses from 110 participants. The level of engagement throughout the weekend was good and there was no shortage of discussion taking place around the response board. There were however two challenging factors that greatly limited the number of responses that were collected.

Figure 4.2 Photograph showing participants in data gathering session one – The Bluedot festival proved to be a very successful location for this research, the response board filled up very quickly and was continuously surrounded by participants, often deep in thought or in deliberation with their group. The Making Rooms pop-up FabLab was extremely popular and busy for the entire weekend duration which meant that there was a constant stream of prospective participants.

The first challenge was the level of involvement required from the researcher in guiding participants through the process. When each potential participant approached the response board, they would be engaged in conversation and the research would be briefly explained to them, before asking if they would like to take part. This usually resulted in worried exclamations that they knew nothing about 3D printing, before reassuring them that that was absolutely fine, and they were still very welcome to take part. It would then be explained to them that there were four different scenarios and that they would be asked to answer the same five questions for each of the scenarios. It had been assumed that this would be a relatively straight forward process and that there would be only a few questions at this stage of the activity. This assumption was wrong. It had not been realised quite how difficult the majority of people found thinking about alternative futures. Despite many efforts to assure the participants that there were no right or wrong answers in this exercise, people were very concerned that they would 'get it wrong'. There was much confusion surrounding who they would be in the future, would they be wealthy? Would they have a new job? Should it be the future that they aspired for? Or a projection of their present selves? Whilst these are all indeed valid considerations, they are not at all what this research is concerned with and certainly not something that had been considered as being a potential obstacle for so many. As a result of this, the research activity was only able to function when the researcher was present, in order to ensure that every participant was given the same information and explanation. Whilst it had been anticipated that some guidance through the process would be required, the extent that this guidance would be needed had been greatly underestimated. Upon reflection it was realised that all of the conversations around the planning of this research activity had occurred with people who had spent much of their lives in a design environment, where the concept of speculating on the future of things is not too uncommon, and so the expectations regarding this were far too optimistic. This experience revealed that those who are not familiar with design education or futures study are not necessarily as comfortable with the process. Whilst the development of participatory tools for futures research is not the primary aim of this research, this is an important point to consider when planning and developing future data gathering sessions.

The second challenge was the speed at which participants were able to complete the activity. What had been envisaged as a quick-fire activity, taking approximately five minutes or so, was in reality a twenty-minute (in some cases longer) task. One of the reasons for this is the fact that many people chose to do this in pairs or as a small group, so there was always a great deal of discussion taking place around the board. This is certainly something that should have been considered more, as it would have then been possible to devise a process by which to record these discussions. One of the main factors affecting the pace at which the participants completed this activity was certainly the difficulty they felt when considering future scenarios, however, once people understood the activity, they were very invested. Participants responded positively and were very concerned with providing well considered responses, so there was a lot more deliberation than had been expected. It also hadn't been considered that people would participate as a group, providing responses as a collective, rather than individually. As such, whilst the total of responses collected was 110, the majority of these represent multiple participants and so the total number of people taking part throughout the weekend was far higher. The board was completed and cleared a number of times throughout the weekend, as a result of this many participants made return journeys to see how others had responded, two versions of the completed board are shown below in figure 4:3.

Despite these two challenges, the numbers that this activity attracted were very encouraging and the general census from participants was that it had been an enjoyable experience, albeit a tricky one. These initial problems helped me to understand what I needed to consider for the following rounds.

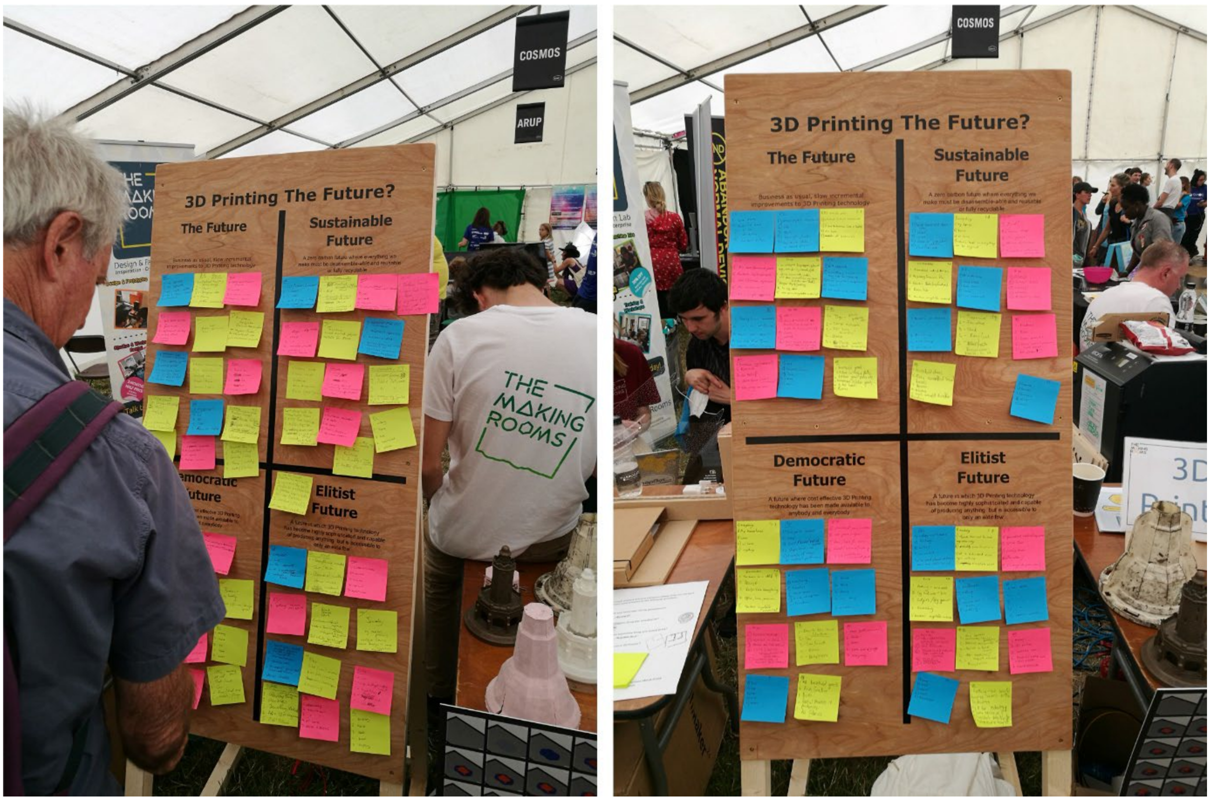


Figure 4.3 Photograph showing the completed response board – Each time the board was filled, the post-it notes were collected and organised into batches for later analysis. The board clearing was carried out six times over the course of the weekend, this led to some participants visiting the response board on multiple occasions to see how others had answered.

4.3.1 The Findings

Over the course of the weekend, two things became very clear; the first being that the majority of people are already aware of 3D printing, the second being that very few people actually understand 3D printing. The most frequent conversation starter went something like 'is that a 3D printer? I've heard of those, but I have never seen one', closely followed by 'I really want one of those'. Many people explained how they had seen 3D printing on television or read about it in a newspaper or magazine, which aligns with the expectations regarding media hype surrounding this technology. As such, their 'knowledge' of 3D printing as a process and its capabilities is very much skewed towards the more fantastical and ambitious versions as presented by much of the media coverage.

The sentiment and narrative of these discussions, when viewed through the critical lens of Rogers' five stages of adoption, can be seen to indicate that 3D printing has already achieved stage one (awareness) and also stage two (persuasion). Whilst the participants were certainly aware of 3D printing and had formed an opinion regarding it, there was less certainty regarding stage three (decision). The overall sentiment of the conversations was undoubtedly favourable towards adopting the technology, but only a very small number of participants had followed through this decision to stage four (implementation). And so, despite the hugely positive attitude towards this technology, there remain barriers to acting upon these favourable decisions.

If these discussions are viewed through the critical lens of diffusion theory, it offers an explanation as to what some of these barriers may be. Whilst the overall attitude towards 3D printing was very favourable, there was clearly a lack of knowledge and understanding of the technology (innovation) itself. Rogers identifies five separate attributes that influence the adoption of the innovation itself, relative advantage, compatibility, complexity, trialability and observability. As there is seemingly a lack of understanding of 3D printing technology, it is understandable that decisions regarding this innovation are difficult to make. What does seem contradictory however is that the communication channels concerning this innovation are clearly very effective. This would seem to suggest that the means by which information concerning this innovation is passed from one individual to another is highly impactful, it is the quality or accuracy of this information that is insufficient.

4.3.2 Applying a Critical Lens

Whilst many of the findings are inferred from the data and discussions with participants and visitors throughout the weekend, the use of Ajzen's *Theory of Planned Behaviour* as a *critical lens* for analysing the data reveals and confirms several key findings. The first determinate of *TPB* to be considered was attitude towards behaviour, which was overwhelmingly favourable towards the use of 3D printing technology. The enthusiasm shown for 3D printing by nearly every one of the 110 participants indicated that for the most part people perceive 3D printing to be something they would be happy engaging with in the future. The sentiment overall was overwhelming positive towards the adoption of 3D printing. In relation to the second determinate, subjective norm, the data suggests that social pressure is very much leaning towards 'performing the behaviour', the behaviour in this instance being the use of 3D printing technology. Although there is no data that directly quantifies this conclusion, the fact that so many participants expected to use the technology in the future without question supports the notion that the use of this technology has already been accepted. The third and final determinate to consider is perceived behavioural control. The data suggests that use of 3D printing technology is perceived to be extremely easy to use. This conclusion is drawn from the fact that whilst participants expected to make use of this technology in the future, to fabricate a wide variety of often extremely complex artefacts, there was very little discussion or quandary regarding the process itself. There was the widespread assumption that the design files required for the fabrication of such artefacts would be readily available and it would be possible to print using any material as required.

When looking at these findings through each of the critical lenses, they lean positively towards the adoption of 3D printing technology by society. However, whilst there seems to be a great deal of excitement and enthusiasm surrounding this technology, this research activity has confirmed the disconnect between expectations and reality. The perception of this technology does seem to be an oversimplified version, whereby material costs and the appropriation of printable design files is seemingly not a consideration.

4.3.3 Discussing the Findings

The goal of this data collection was to establish a baseline understanding of the current expectations and anticipations, held by the public, for the use of 3D printing in the future. We achieved the goal in this regard, having collected responses from 110 participants, providing a broad range of opinions which confirm some of the earlier assumptions, but also provide new insights. For example, it was suspected that there was a disconnect between the capabilities of the technology that is currently available and those of its perceived capabilities, but what had not been anticipated was the extent to which people expect to engage with the technology.

For this data gathering session the number of participants who responded a certain way is less useful than the range of their responses, as it is the range of responses that collectively help to describe the people's expectations from this technology. This being said, in order to make sense of this data it has been collated and entered into data tables. The results discussed here are highlights of these findings and those which have been extrapolated from these data sets, as shown below (see figures 4.4 - 4.8). The data represented in the graphs represents the combined results from each of the four future scenarios, the separate data sets for each of these questions and scenarios can be found in the appendix to allow for a more granular understanding of the results.

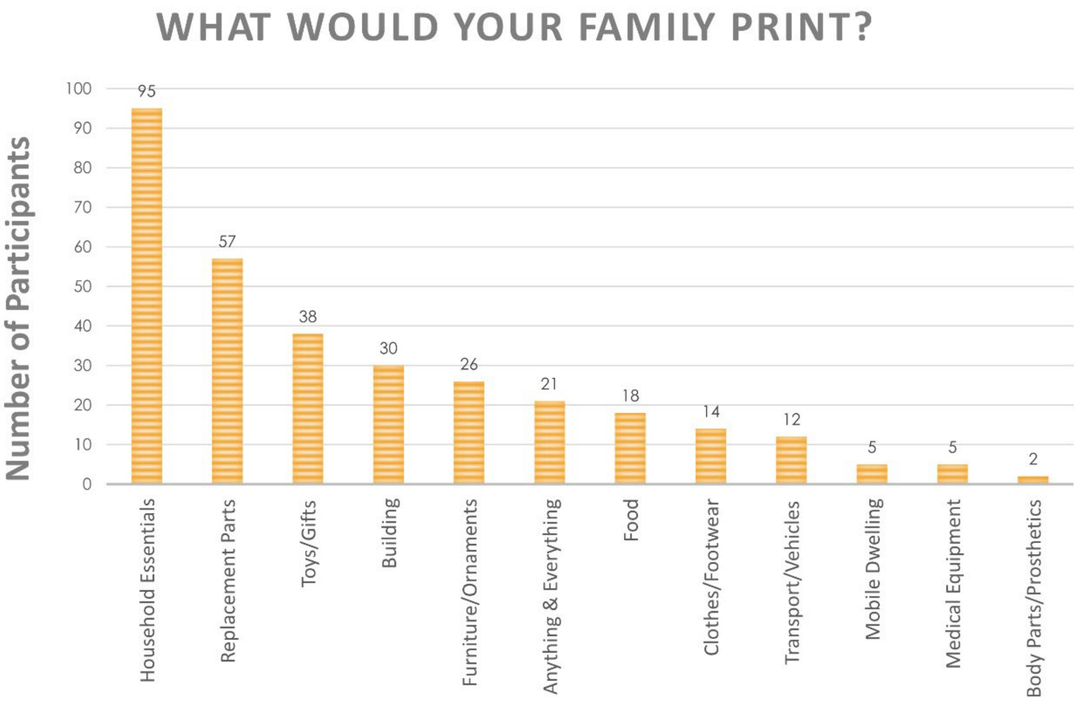


Figure 4.4 Graph showing the results to the question, What would your family print? – These are the combined results for this question across all four of the future scenarios. Household essentials was the most popular answer for all of the future scenarios, with the exception of the Elitist Future, which had Building as the most popular response. Replacement Parts was the second most popular response for The Future and Sustainable Future scenarios, Anything and Everything was the second most popular response for the Democratic Future

scenario, and in an Elitist Future scenario the second most popular response was a Vehicle. It is worth noting that a large number of participants responded to questions concerning the Elitist Future by simply stating that they did not think they would be a part of this future.

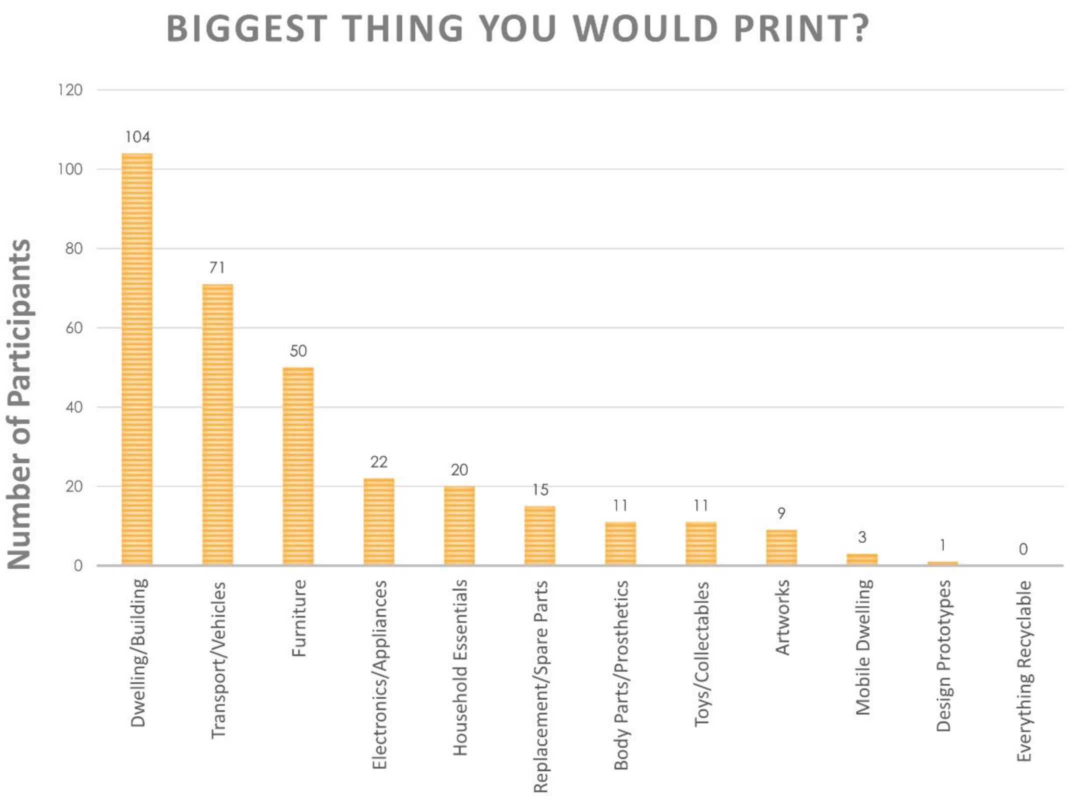


Figure 4.5 Graph showing the results to the question, What is the biggest thing you would print? – These are the combined results for this question across all four of the future scenarios. A Building was the most popular answer for all of the future scenarios, with the exception of the Elitist Future, which had A Vehicle as the most popular response, with a Building being the second most popular response. The second most popular response for both The Future, and Sustainable Future scenarios was Furniture, followed by Vehicles, whilst for the Democratic Future it was Vehicles, followed by Furniture. Interestingly, considering how highly these responses were received for the three scenarios already discussed, for the Elitist Future there was not a single suggestion of Furniture, the third most popular response was instead Electronics and Appliances, closely followed by Prosthetics.

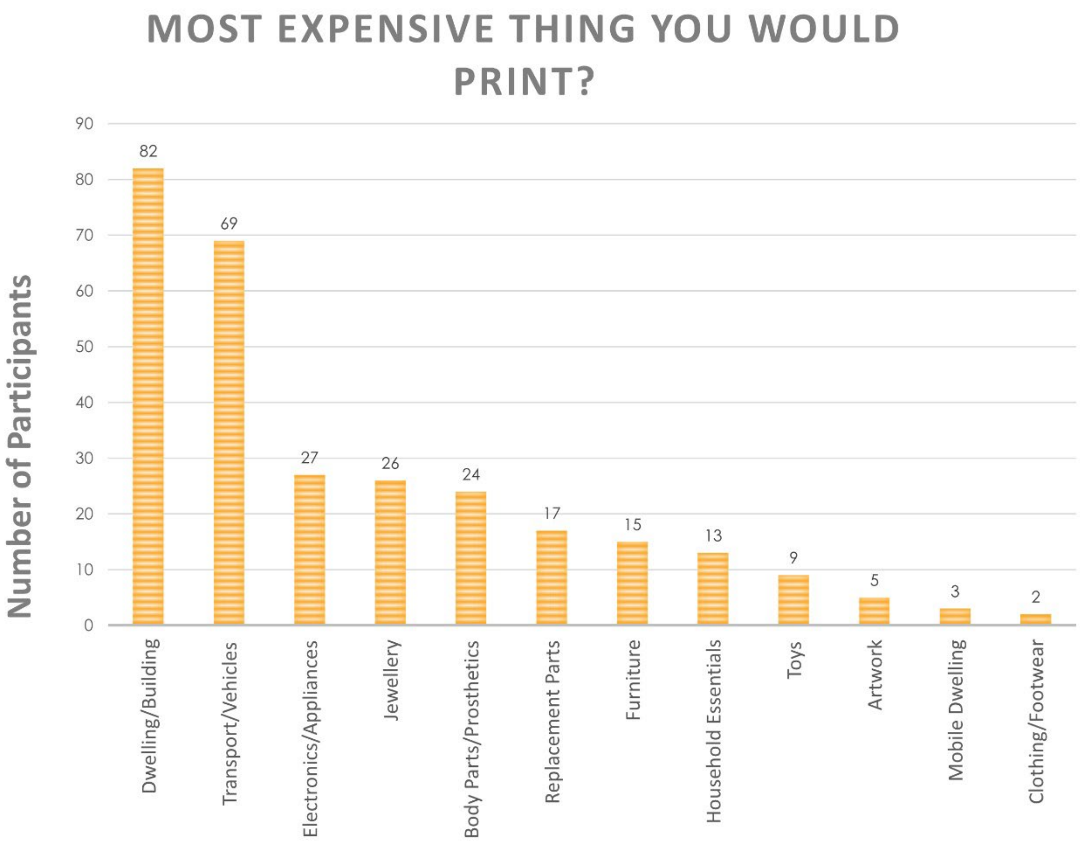


Figure 4:6 Graph showing the results to the question, What is the most expensive thing you would print? – These are the combined results for this question across all four of the future scenarios. A Building was the most popular response across the three scenarios, The Future, Sustainable Future and Democratic Future, with Vehicles as the second most popular response. Vehicles was the most popular response for the Elitist Future, followed by a Building, which was a little unexpected to begin with, but then upon closer inspection, many of the expectations were for cruise ships and spaceships etc. The results for the remaining categories varied greatly across all four of the future scenarios.

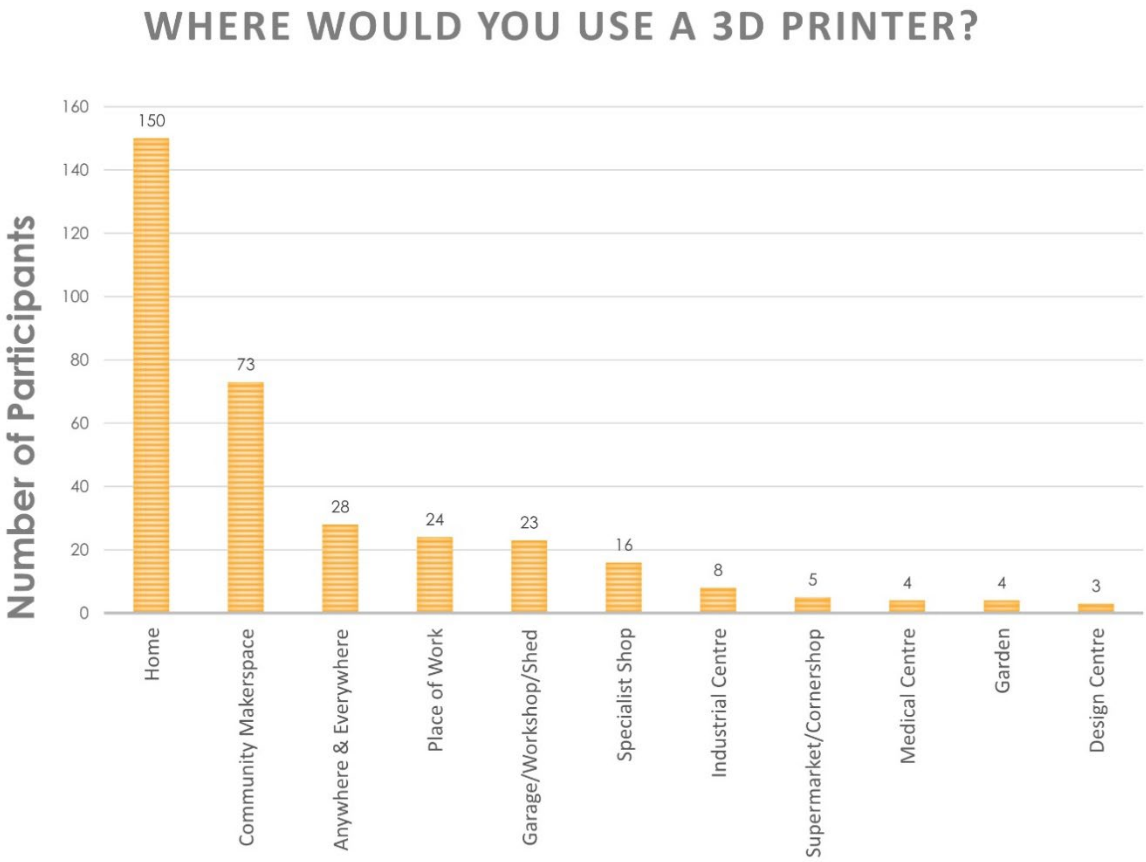


Figure 4.7 Graph showing the results to the question, Where do you expect to use 3D printing? – These are the combined results for this question across all four of the future scenarios. By far the most popular response across all four of the future scenarios was for a Home Environment, followed by a Community Makerspace, with the exception of an Elitist Future which received very few responses for this category. For the Sustainable Future scenario there were equal responses for both the Home and Community Makerspace.

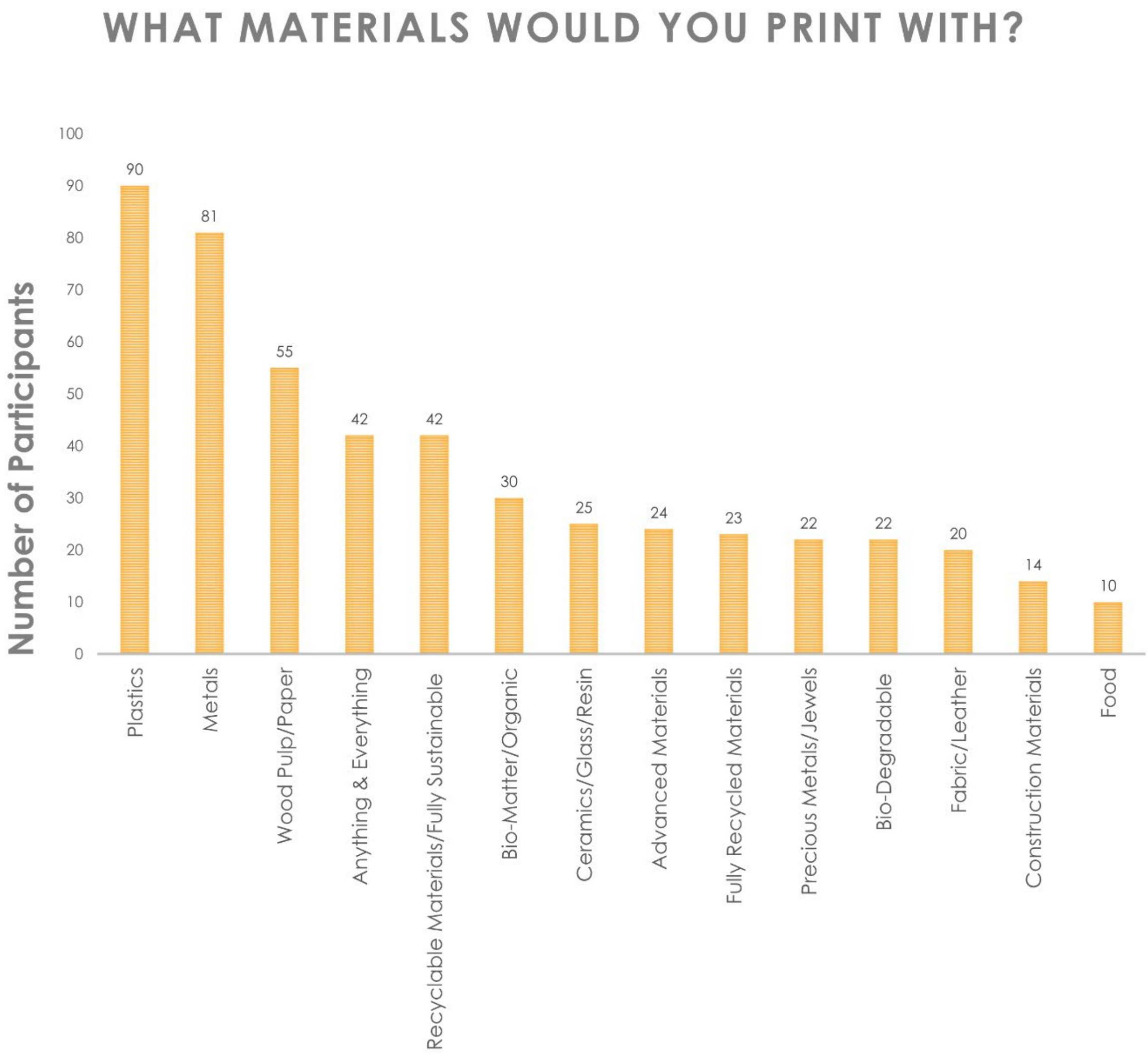


Figure 4.8 Graph showing the results to the question, What materials do you expect to print with? – These are the combined results for this question across all four of the future scenarios. Unlike the responses for the previous questions, there was very little consensus across the different scenarios.

One of the most prominent findings is that the majority of participants aspired to own or at least regularly engage with 3D printing technology in the future. This of course could be influenced by the nature of this activity, but whilst there were many questions concerning how people should imagine their future, none questioned their access to this technology. Whilst this research activity was focused on the adoption of this technology, which could be considered as leaning towards a particular outcome, the venue had many different types of technology being demonstrated, yet it was 3D printing that received the most attention and elicited the most excitement. The only instance in which a high number of participants suggested they would not have access to 3D printing technology was in the Elitist Future scenario. Some explained that this was because they did not imagine that they would be members of the elite group who had access to 3D printing. Discussions with others around this topic alluded to the fact that whilst they expected to regularly use 3D printing technology once, or if, it became domesticated or easily accessible, there was little appetite for being early adopters of the technology. This confirms that ease of use and ease of access to this technology is therefore a key driver for the successful diffusion and adoption of technology (Ajzen, 1991; Rogers, 2003).

The responses suggest that there is the strong expectation that 3D printing will become ever-present in our lives and will successfully diffuse into society. Though as predicted, the expected use cases for this technology are more aligned with science fiction than reality, which could prove problematic and undermine the adoption and diffusion of this technology when people discover this disconnect (ibid.). For example, the responses included a wide range of prospective items for printing, many of which are highly unsuitable for the process. Popular responses were buildings and vehicles, highly complex constructs typically comprised of many components fabricated from a wide variety of materials. Whilst there are 3D printers capable of printing in many of the materials that would be required, and there are existing multi material printers, the sheer complexity required for a device which was capable of 3D printing a house or vehicle (as we understand them today) in its entirety is far beyond our current capabilities. The disparities between the expectation for 3D printers and our present capabilities are magnified even further when considering the sophistication and capabilities of consumer level 3D printers.

This disconnect between the expectations and the reality of consumer 3D printing is perhaps to be expected, after all the questions asked were concerned with the future of this technology. Despite it being possible that 3D printing processes could become sufficiently sophisticated as to be capable of manufacturing complete buildings and vehicles, there is still going to be the issue of cost, something that very few participants seemed to consider. Whilst access to a 3D printer can reduce costs by removing transportation and manufacturing costs, the cost of the raw materials in the quantities required will still be considerable. It is possible that again, this disparity between expectation and reality is due to the nature of this research being futures oriented.

Previous experiences in makerspaces meant that it was anticipated that the expectations for 3D printing technology would far outweigh its present capabilities. What was not anticipated however was how literally many participants seemed to be taking the much-used marketing statement [with 3D printing] 'you're limited only by your imagination' (MakerBot, 2015). Whilst some degree of imagination is necessary when speculating on the future uses of a technology, some of the results received seem to move beyond this. For example, several participants responded to questions regarding an 'Elitist Future' with the suggestion that they would 3D print an aeroplane, an exoskeleton or weaponry, whilst these may be very ambitious for present day consumer technology, it is imaginable that one day in the future this could be possible, assuming the capabilities of industrial technology trickles down. What is perhaps less imaginable though is a future in which we could 3D print a 'hoverboard' or a 'spaceship', not necessarily because we lack the technology to manufacture such things, but because such things have yet to be invented. As has already stated, this does fall within the bounds of an imagined future, but it also indicates that people are indeed expecting very few limitations from this technology in the future and there doesn't seem to be any consideration for the costs associated with this process.

All of the questions posed in this data gathering session focused on the potential outputs from 3D printing, what was interesting however, was that during the numerous discussions that occurred around the activity board, mention of the design files themselves or the cost of materials were for the most part completely absent from the conversation. No 3D printing of any kind can take place without first having an appropriate design file (and subsequent print files) and in many instances (other than simple plastic artefacts) a 3D printed object or artefact would be far too cost prohibitive when compared to a non 3D printed version of the same object.

Arthur C. Clarke (1984: p.38) once wrote that “any sufficiently advanced technology is indistinguishable from magic”, and despite the process of 3D printing being an observable application of science and technology, ‘magic’ was still the way that many people chose to describe the process of 3D printing upon seeing it for the first time. This also supports the perception of 3D printing as a mystery ‘black box’ (Stahl, 1995), whereby objects and artefacts ‘magically’, instantly appear. This is likely due to the public perception of 3D printing as a product-orientated technology, being that this is the way the technology is promoted. Users are familiar with advertisers presenting a more streamlined experience, such as iPhone adverts which are accompanied by the disclaimer ‘sequence shortened’ (Palazzolo, 2012), and as such there is an acceptance that the experience will not necessarily be as shown. In this instance however, the difference between the expectation for instantaneous 3D prints compared to the reality, is hours and even days as opposed to seconds and minutes. Amongst the most popular responses for each of the scenarios was the expectation of 3D printing a building or transportation of some kind, both of which would require highly sophisticated designs and a large palette of materials, both of which would likely have a large impact on the cost of such an undertaking, regardless of the future scenario this was taking place in.

4.3.4 Summary of Findings

The picture painted by the findings of this data gathering session and the discussions that occurred around it, suggest a future world where 3D printing is very much an accepted technology, that is widely used on a daily basis. It is expected that this technology can be engaged with at a wide variety of locations, but most commonly in a domestic environment, and is capable of processing almost any materials required. Certainly, the types of questions being asked will have encouraged the participants to consider potential uses that sit at the boundaries of their expectations, but the prevailing expectations for 3D printing were very reminiscent of the “pop” futures for this technology that are frequently portrayed in the media and had been predicted at the outset.

4.4 Conclusion

There are two main conclusions that have been drawn from this stage of the research, the first relates to the design of the research activity itself and the second to the findings themselves. In relation to the design of this research activity, there was a great deal of concern around the ability to attract a suitable number of participants for the findings to be of use. As such, several compromises were made, regarding the number of questions to be asked and the depth of enquiry which was levelled at the participants themselves. Having experienced this participatory approach to research however, it is evident that once somebody has agreed to participate, they are far more willing to invest their time than had been anticipated. The original assumption had been that people would need persuading and convincing to participate, which could be a struggle when they were faced with so many other options for activities and talks to attend. The reality was far different however, once people had engaged with our demonstration stand, they were typically very keen to share their thoughts and enter into a discussion concerning what, for many of them, was a new technology. This experience suggests that when given the opportunity, in an appropriate context, the general public are very enthusiastic to contribute to research, rendering much of the earlier concern moot.

Regarding the data that was collected, it strongly indicates the general public expect to engage with 3D printing in the future, however, how they intend to do so is far from clear. This is partly due to the questions that this research asked, and because of the broad range of responses that the public provided. While this was successful for providing a baseline for the expected use cases for 3D printing technology, it would have been beneficial to also use this data gathering session to uncover greater detail as to how exactly the anticipated engaging with this technology. The questions posed to the participants were intentionally open, as to not influence their responses and to make it a more inviting and easier process for the participants. The experience from this first data gathering session however has shown that people are far more willing to take part in research discussions and contribute their opinions than had been anticipated, and as such it would likely have been successful had the questions been much more in depth and detailed.

As a result of this, the range of responses paints a very confusing picture and suggests that whilst awareness of 3D printing technology is high, knowledge and understanding concerning 3D printing is very much lacking. This is perhaps understandable considering the huge amount of hype that surrounded its release into the consumer market, unless participants have experienced the technology personally, they have no reason to question the accompanying hyperbole. Unfortunately, as has already been stated, the questions asked did not enable anything more than speculation on why this may be. Whilst the participants were aware of what they expected, there was no mechanism to record their thought process or for them to further articulate their thoughts. More specific questions could allow me to glean more insights into how they view 3D printing technology. On reflection the open nature of this first round of data collection may have given the participants too many options, though this did allow them the opportunity to include things that had not been anticipated. There was also the expectation that further rounds of data gathering would be required, so the lessons learned from this initial round would be used to inform the design of data gathering session two[10].

Having observed this initial data gathering session and analysed the data, these findings indicate that whilst 3D printing is already a reality, the participants in this study are not yet able to differentiate between the science fact and science fiction regarding this technology. There is clearly a high level of awareness for 3D printing, but the level of knowledge is very limited. Though this is unsurprising considering the overwhelmingly positive hype that surrounds this technology and the comparatively

[10] The lessons learned from this session are discussed in the following chapter as part of section 5.2.1 Designing the Research.

low trialability (Rogers, 2003), resulting in the media slogans and hype that accompany this technology being accepted without question.

The primary insights that will be informing data gathering session two are first and foremost, the level of enthusiasm that people exhibited for participating in the research was far beyond what was expected. A major concern had been the ability to attract a sufficient number of participants, which had been a primary driver for the design of this research activity. In practice, people were extremely willing to share their thoughts and ideas, though it is assumed that this is helped by the research subject being surrounded by much hype. Another lesson learnt was the importance of sufficiently focusing the research activity. This data gathering session was designed to be intentionally open, in that there were no boundaries or constraints for the participants to work within, other than the simple questions being put to them. It had not been considered how daunting a task this could be, akin to the *tyranny of choice* paradox. A more constrained research activity could make it easier for the participants to both understand what is being asked of them, and easier for them to complete the task. This conclusion is drawn from the experience of this initial data gathering session, the second data gathering session will seek to quantify and build upon these theories.

5.0 Data Gathering Session Two: Questionnaire

5.1 Introduction

This chapter describes the second of three data gathering sessions, designed to gather data relating to people's current understanding of 3D printing technology. This begins with an explanation of the design process for this round of data collection and how this was informed by the experience of, and findings from, data gathering session one. The data gathering activity itself is then described, discussing the successes and failures, before moving on to the findings themselves. The findings are then analysed using the critical lenses, before outlining key findings from each set of questions. This chapter then concludes with an overview of data gathering session two, outlining how these findings compare and relate to those from data gathering session one.

5.2 Planning

The experience of the first data gathering session suggested that people were far more willing to contribute and participate in research than had initially been expected. The design of the first had included interactive elements in efforts to encourage participation in this research, due to concerns concerning the ability to attract participants to this research when it was surrounded by so many other engaging things to do. However, the experience from the first data gathering session showed that people were very happy to share their thoughts, and the design of the research activity played less of a role in attracting participation than had been expected. As such, it was considered less important for the second data gathering activity to be interactive, it could also be more in depth and targeted than the first. Whilst planning this second data gathering session it was confirmed that *The Making Rooms* had been invited back to attend the 2019 Bluedot festival. This would once again provide many potential participants for this research, further confirming the plan for a more in depth and less interactive activity, considering the experience from Data gathering session One. A second issue that needed addressing was the level of involvement required of the primary researcher when carrying out the research activity, Data gathering session One had been far more involved than had been intended. Therefore, Data gathering session Two was intended to be a far more self-explanatory and require as little guidance as possible, allowing for more people to participate.

For these reasons, the chosen format for Data gathering session Two was a questionnaire, as this was something that could be quickly and easily handed out to people who may be queuing for other activities, near *The Making Rooms* exhibitor stand. Another benefit of a questionnaire is that it is a commonly known format, so very little input or explanation would be required by the researcher. Knowing that this data gathering session would once again be taking place in a festival location, it was considered wise to limit the length to a single sheet of A4 paper, considering that tables or other suitable writing surfaces would not always be readily available. An added benefit of this approach would not only make it easier and more manageable for participants but would also mean that there was no risk of getting data sets mixed up or confused, something which has already been highlighted as an issue for data gathering session one.

Another aspect of the data gathering session that needed addressing, was the process of how the findings are analysed and interpreted. Whilst Data gathering session One had gathered a wide range of rich data, the analysing process was overly complicated and not easily replicable, being that much of the interpretation was reliant on, and derived from the conversations which had accompanied the written responses. The use of a questionnaire format for this second data gathering session would make the subsequent data collation and analysis much clearer and more easily replicable as a process.

The questions posed in the first data gathering session were intentionally open, in efforts to allow every participant as much freedom in their responses as possible. Through the analysis of this data, several clear trends emerged which were used to inform the questions for the second data gathering session. Each of the questions was a simple multiple choice or sliding scale, with the questionnaire comprising three distinct parts.

5.2.1 Designing the Research

Part one (Questions 1-5) of the questionnaire was concerned with collecting data on the demographic of participants. Whilst this research does not aim to gather 'Big Data' sets or to make claims regarding any one group of society, it was considered that having the ability to separate the data in this manner could be beneficial when analysing the results and may offer some insights. The decision process for the most appropriate criteria for the initial section deferred to the guidance of the Office for National Statistics (Office for National Statistics, 2019)and Gov.uk (GOV.UK, 2019) (as shown in figure 5.1).

Age:		**Gender:**	**Ethnicity:**
☐ 18-24	☐ 25-34	☐ Male	☐ White
☐ 35-44	☐ 45-54	☐ Female	☐ Asian/Asian British
☐ 55-64	☐ 65+	☐ Other	☐ Mixed/Multiple ethnic backgrounds
		☐ Prefer not to say	☐ Black/African/Caribbean/Black British
Education: What is the highest qualification you have completed?			
☐ GNVQ / Apprenticeship		☐ Postgraduate / Masters Degree	
☐ GCSE / O-Level or equivalent		☐ Doctorate	
☐ AS / A Levels		☐ Professional Qualification	
☐ Undergraduate Degree		☐ Other (Please Specify)	....
Profession:	....		

Figure 5.1 Part one of the questionnaire – The first section focused on collecting demographic information from each of the participants, whilst this was not anticipated to be strictly necessary, it was included to see what (if anything) this would uncover.

Part two (Questions 6-15) of the questionnaire was informed by Rogers Diffusion Theory (Rogers, 2003) which forms the third critical lens of this research. As has been discussed in Chapter Three, Diffusion Theory is comprised of four primary components: the *Innovation* itself, *Communication Channels*, *Social System* and *Time*. Whilst the results from data gathering session one did allow the inference of a great deal of information, which could be understood in relation to each of these four stages, the aim of data gathering session two was to be much more explicit in this regard.

Questions five to nine relate to the Innovation itself, which can be influenced by five separate attributes: relative advantage, compatibility, complexity, trialability and observability. Each of these attributes is therefore the subject of its own question. Questions ten to twelve then focus on Communication Channels, Time and Social Systems respectively. Questions thirteen to fifteen can also be considered as relating to Communication Channels, but their inclusion is more concerned with understanding the participants level of awareness regarding the maker movement.

The objective of these questions was to uncover the level of knowledge that each participant had regarding 3D Printing. This was something discussed a great deal during data gathering session one, but any data concerning this was unfortunately not captured. The inclusion of this set of questions would reveal if participants were responding based on their experience of using 3D printing technology, or merely sharing their expectations based on what they have heard about the technology. This set of questions was arranged as shown in figure 5.2.

Do you think it would be useful to have a 3D Printer at home? (indicate on the scale below)

Not at all **Most definitely**

Have you used any device or technology that is similar or related to 3D Printing before?

☐ **Yes** ☐ **No**

How easy / difficult do you think 3D Printing is? (indicate on the scale below)

Very Simple **Extremely Difficult**

Have you yourself had any experience with 3D Printing? (this can include observing it)

☐ **Yes** ☐ **No**

Do you know where you could buy or rent a 3D Printer?

☐ **Yes** ☐ **No**

Where did you first learn about 3D Printing?

☐ **Word of mouth** ☐ **Radio**

☐ **Television** ☐ **Newspaper**

☐ **Online** ☐ **Other (Please Specify)** ....

Do you know somebody who owns a 3D Printer?

☐ Yes, I do ☐ Yes, somebody else I know ☐ No

When do you imagine you will have a 3D Printer at home?

☐ This year	☐ + 1 Year	☐ + 2 Years	☐ +3 Years	☐ +5 Years
☐ +7 Years	☐ + 10 Year	☐ + 15 Year	☐ +20 Year	☐ Never

Do you like to make things yourself?

☐ Yes ☐ No

Have you heard of the Maker movement?

☐ Yes ☐ Yes, but I dont know what it is ☐ No

Would you call yourself a Maker?

☐ Yes ☐ Maybe ☐ No ☐ I dont know

Figure 5.2 Part two of the questionnaire – This section comprised questions relating to the four primary components of Rogers' Diffusion Theory (Rogers,2003)*. These questions appear in a different order then when discussed in the methods chapter, this was done to create a series of questions that I felt flowed more smoothly making it easier for the participants to consider their response.*

The final set of questions (Questions 16-19) are similar to those posed during Data gathering session One, and are concerned with uncovering participants expectations and anticipated uses for 3D Printing technology, if and when they engage with it in the future. The categories that make up the multiple-choice responses were informed by the findings from Data gathering session One, taking the most common results, but also providing the opportunity to specify any other of their own choosing. The inclusion of these questions was intended to firstly confirm or contradict those findings from Data gathering session One, and secondly to provide more granular and focused data on if, how, and where people see 3D printing technology playing a role in their lives [Fig. 5.3].

Each of the data gatherings sessions was covered by the initial ethics approval application. Once again, prospective participants were provided with a brief explanation of the process and a participant information form was provided to explain the process in more detail. Once they had read and understood the participant information form, they were given the opportunity to ask for further clarification or explanation about anything they were unsure of. Each individual was then provided with a consent form to complete prior to taking part in the process.

Where do you expect you would use a 3D Printer in the future? (select as many as you like)			
Makerspace	Everywhere	Home	Community Centre
Place of work	Specialist shop	Other (Please Specify)	....

If you did have a printer at home, where would you put it?			
I wouldn't	Garage	Kitchen	Dining Room
Living Room	Bedroom	Other (Please Specify)	....

What materials would you expect to print in? (select as many as you like)			
Plastic	Metal	Fabric	Recycled Materials
Ceramic	Wood	Other (Please Specify)	....

What do you expect to use a 3D Printer for?

Figure 5.3 The final section of the questions – This section relates to participants expected future use cases for 3D Printing technology. These multiple-choice answer options were informed by the findings of data gathering session one, but there was also the provision for participants to provide an answer that fell outside of these options.

5.3 The 2019 Festival Experience

This second data gathering session had been designed on the understanding of having similar conditions to those of the first data gathering session, considering that once again it would be occurring at the Bluedot Festival. However, it quickly became clear that the 2019 festival experience was going to be extremely different to that of 2018. The first obstacle was the weather, which had two major impacts on the first of three planned days for data gathering. The first impact was to dramatically increase the setup time for the exhibition area, affecting both the time it took the team to pack and load all the equipment at the FabLab, and the time it took the team to unload and setup the equipment upon arrival at the festival site. The second major impact was a dramatic reduction in the footfall on day one, with many visitors electing to remain in their tents at the campsite, rather than venturing into the exhibitor's area. Upon setting everything up it was also discovered that no power connections had been supplied to the exhibition tent, it was therefore impossible to run any of the equipment. This issue was eventually resolved in the mid-afternoon, though this did result in a sizable reduction in the available time to hold the data gathering session as planned.

Overall footfall for the duration of the weekend was also negatively impacted by the placement of the exhibition tent, when compared to the previous years. Due to a scheduling and communication error with the festival organisers, *The Making Rooms* was positioned in the farthest area of the festival site, as opposed to the main exhibitor's area, as had been the case previously. Thankfully the weather, with the exception of a few light showers, did improve greatly for the remainder of the weekend, and data gathering session two was able to commence. Unfortunately, not only was the location far less favourable than the previous year, but the layout of the exhibitor spaces was also far less conducive to engaging with visitors as they waited for activities [Fig. 5.4]. It was therefore regrettable that the interactive element of the research gathering process had been deemed unimportant, as in this new context, it would have been beneficial. Despite the conditions being very different than those which had been planned for, the research was nevertheless received well and there were still many people interested in sharing their thoughts.

Figure 5.4 Photograph showing the location and setup for data gathering session two – The location and setup of The Making Rooms *mobile* FabLab *at* Bluedot *2019 was very different to those expected, and the conditions did not match those that this data gathering session had been designed for. Regardless,* The Making Rooms *pop-up* FabLab *proved to be a popular draw, with long persistent queues throughout the weekend, providing suitable participants for the questionnaire.*

At the close of the festival weekend, data gathering session two had collected fifty-six completed questionnaires, and once again there had been numerous interesting discussions concerning 3D Printing. However, this number was far less than had been anticipated, when considering the experience of Data gathering session One. Whilst this research was not concerned with gathering large data sets, and there was not necessarily a lower limit on the number of required participants, the intention had been to collect a comparable number of responses to Data gathering session One. As such, soon after the festival weekend, several locations were chosen for a further round of data gathering. These were, *The Making Rooms* in Blackburn, Lancashire, *The Manchester School of Architecture,* Manchester and *Lancaster Institute for Contemporary Arts*, Lancaster. These locations were selected as they provided a similar demographic of people to the Bluedot festival, primarily those who are likely to be aware of 3D printing but have not necessarily engaged with it. With these additional rounds of data collection, the number of completed questionnaires reached one hundred and sixteen. The data sets from the secondary round of Data gathering session Two were kept separate from those of the initial round of Data gathering session Two, as a precautionary measure, should the results prove to be dramatically different, as this would be another point of interest for this research.

5.3.1 The Findings

One of the primary differences between the first, and this second data gathering session, was the inclusion of questions pertaining to demographics. It was never the intention to collect large data sets, so there was not necessarily any consideration given to making meaningful inferences regarding any of the responses and the specific demographic groups they may belong to. It was however expected that the questionnaire would collect results from a greater number of participants than the 110 who had taken part in data gathering session one. Whilst this second data gathering session did attract participation from 119 people, this was still too small of a data set to indicate any major patterns or trends. Despite this additional data not revealing anything of interest, it was nonetheless a worthwhile effort considering the potential benefits from this line of questioning. Therefore, being that the first section of the questionnaire did not reveal anything meaningful, the first set of results that will be discussed are those relating to the *Innovation* itself.

5.3.2 Four Components of Diffusion

The first set of results for discussion are those relating to the perceived Compatibility and Observability (Rogers, 2003) of 3D Printing, as these revealed if the participants expectations for this technology were based on some level of prior experience, or purely conjecture. That is not to say that this question is more important, merely that this offers an interesting angle to view the subsequent data.

The results show that in terms of compatibility of the innovation, less than half of the participants had experience using a device or technology that they considered to be similar to 3D printing. When considering observability of the innovation however, two thirds of the participants had some level of experience with 3D printing itself (as shown in figure 5.5). Following these results, each of the subsequent result charts also keep track of and indicate this information (with the colour teal representing those who have experience with 3D Printing technology, and those without experience represented in orange) to aid in better understanding how this attribute leads to an innovations adoption.

Following on from compatibility and observability, the most relevant data set to next consider are those relating to the perceived relative advantage and complexity of 3D Printing technology (as shown in figure 5.6). These are key determinants, as innovations which are perceived to be better, will be adopted more quickly. For the relative advantage (as shown in figure 5.7) the results show that only a very small number of participants felt that a 3D printer would be of no use at all. Whilst the majority felt it would be useful to some extent, these results indicate that this innovation is not yet widely perceived to be a must have device in the domestic environment. It was interesting to note that of those participants who had some previous experience with 3D printing, their choices were spread relatively evenly across the scale, whereas those without prior experience were slightly more optimistic or expectant in their responses. In terms of the innovation's complexity, participants from both camps showed similar judgement, but with a clear majority erring on the side of caution and taking a neutral stance.

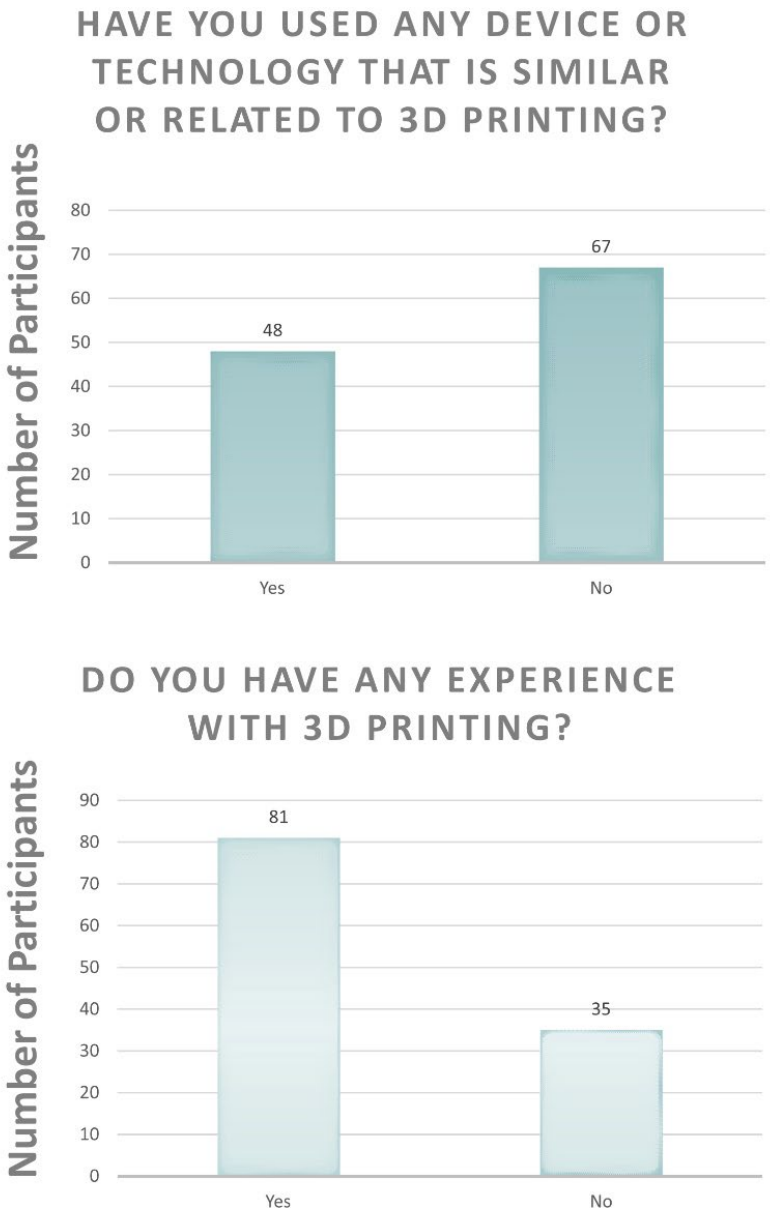


Figure 5.5 Graphs showing the results for questions relating to compatibility and observability of the innovation – The results relating to the Compatibility and Observability of the Innovation – 3D Printing. In terms of compatibility, 3D Printing does seem to be considered a device unlike any other by the majority of participants, whilst this could be due to people's inexperience with this technology or other digital fabrication devices with which to compare it, the majority of participants however confirmed that they did have at least some level of experience with 3D Printing technology.

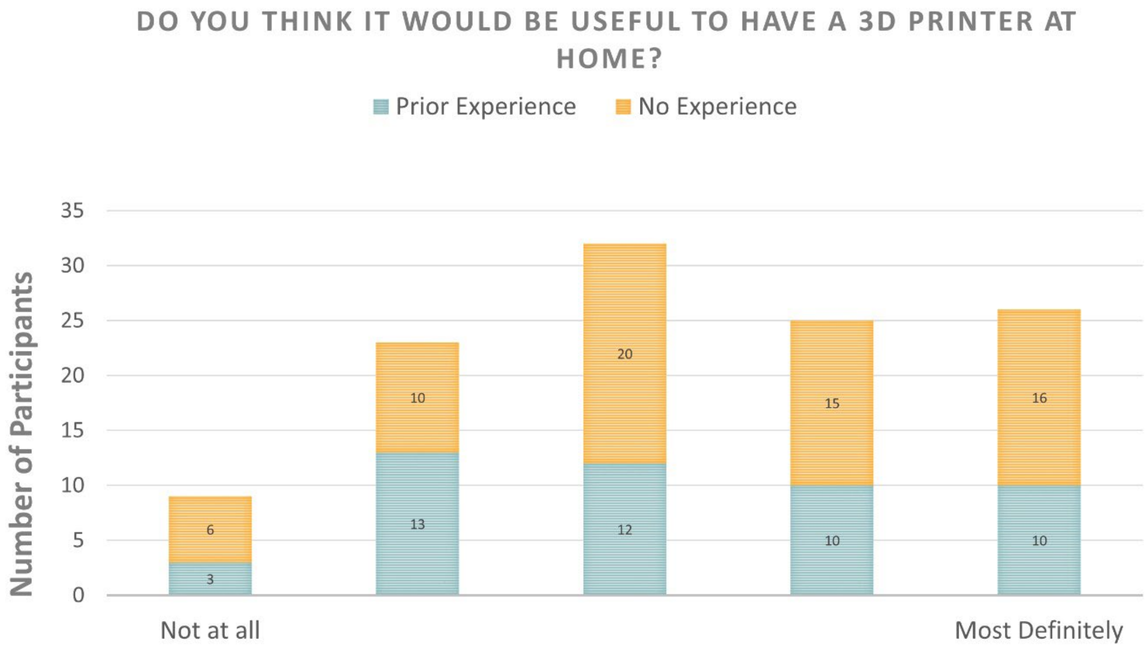


Figure 5.6 Graph showing the results relating to the perceived relative advantage of 3D printing in the home – Those who did have some experience of 3D printing were slightly more inclined to respond positively to this question, though overall most participants did consider there to be some advantage to having access to 3D printing at home.

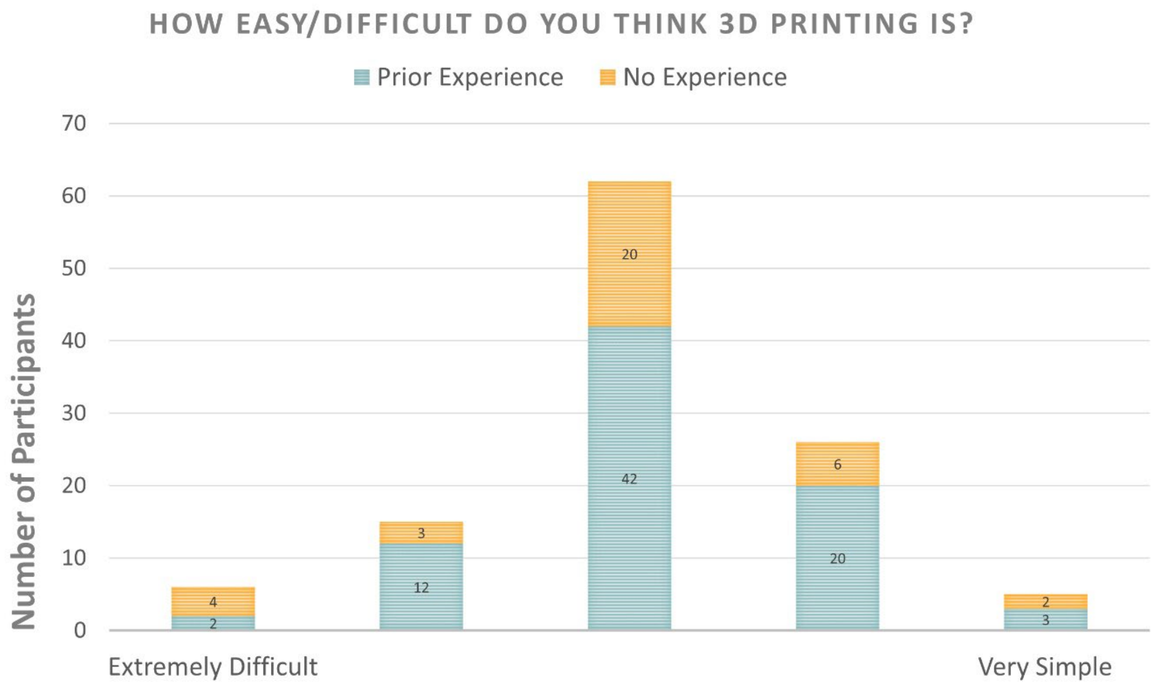


Figure 5.7 Graph showing the results relating to the complexity *of the innovation – These results indicate that in terms of complexity things look more positively, but not emphatically so and once again a relatively even balance from those with and without experience.*

The final question relating to the innovation itself was concerned with the *trialability* of 3D Printing, the results of which are shown in figure 5.8. The results were once again relatively evenly spread and perhaps unsurprisingly, those who had experience with 3D printing technology were slightly more likely to respond positively.

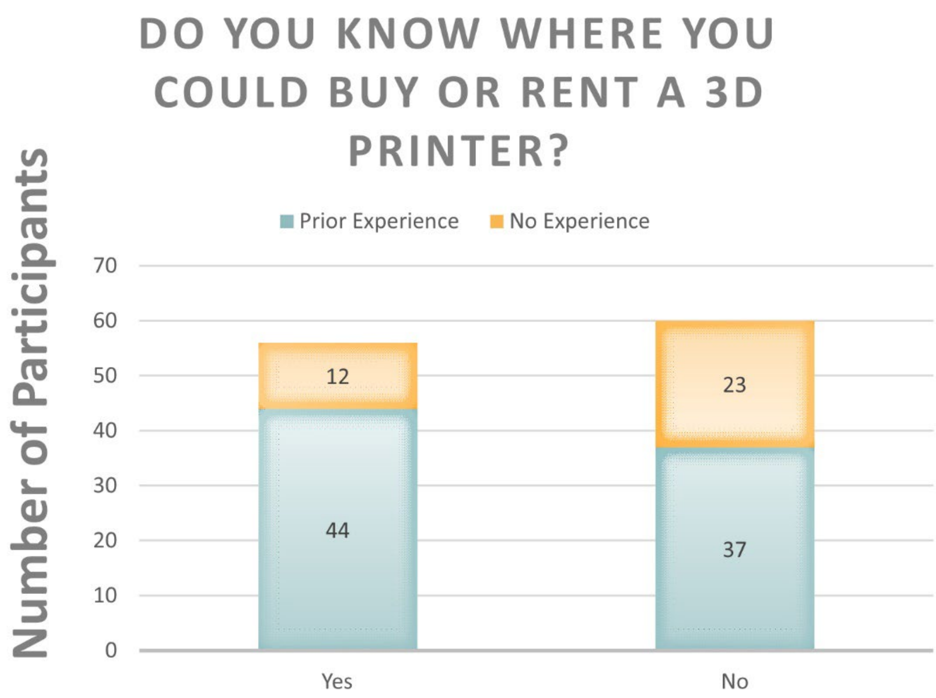


Figure 5.8 Graph showing the results relating to the trialability of the innovation – These results indicate that the number of participants responding either way is relatively evenly split, and there seems to be only a slight difference for those who do have some level of experience with the technology.

In terms of the Innovation itself then, these results suggest that whilst the overall attitude towards 3D printing leans to a positive view, there is far more progress to be made if successful adoption is to be assured. As has been previously discussed however, there is far more to a technology's adoption than the innovation itself. The next primary component to consider was *Communication Channels*, in order to understand how successfully information concerning 3D Printing is being conveyed, as this is essential for the diffusion of technology.

The results, which are shown in figure 5.9, were somewhat surprising, as word of mouth or education were not expected to be amongst the most popular responses and online underperformed compared to the expectations. What these results do suggest however, is that the communication channels concerning 3D Printing are very effective.

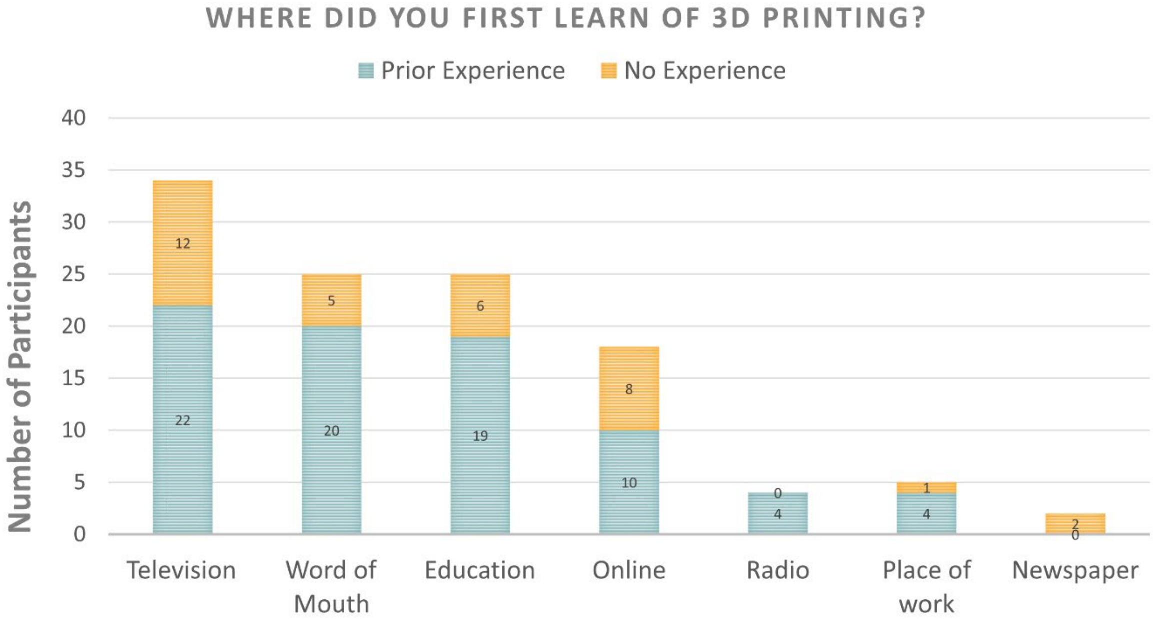


Figure 5.9 Graph showing the results relating to the communication channels of the innovation – These results show the responses from those with and those without prior 3D Printing experience. Whilst the majority of these communication channels appear very active, higher responses were expected for the more traditional media outlets and Education had not previously been considered a major channel of communication, considering this research only engaged with those over 18 years of age and consumer 3D printing is a relatively new concept.

The third component of Rogers' diffusion theory (2003) that these questions targeted was *Social System,* which influences and affects how an innovation infiltrates a population. Whilst it may seem obvious that those who had no experience with 3D printing were far more likely to also not know anybody who had a 3D printer, what was surprising was the number of people who had experience with the technology but did not know anybody who had a 3D Printer, (as shown in figure 5.10 below).

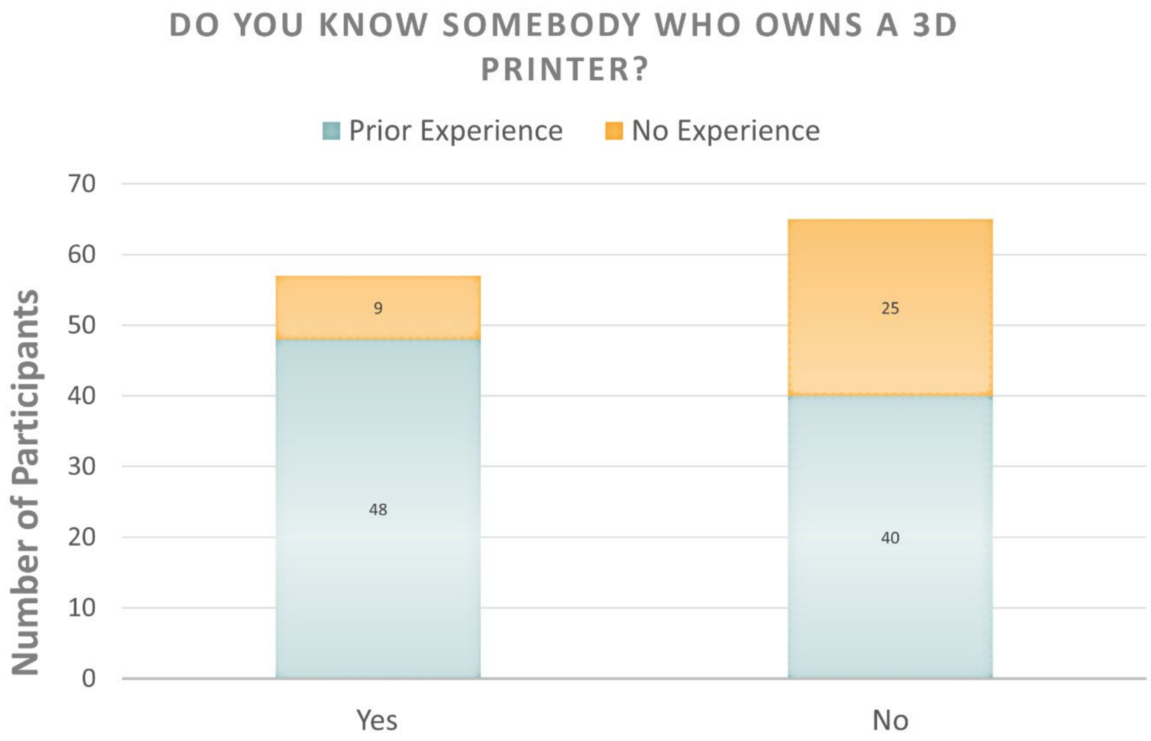


Figure 5.10 Graph showing the results relating to the social system – These results indicate the responses from those with and those without prior 3D Printing experience. It is worth noting that the results shown here with a response of yes represent the sum of those who responded Yes and Yes, I do to the original question. I decided that this was necessary as on reflection this was a rather ambiguous choice of phrasing and could have misled participants, I therefore have combined the results to indicate either a positive or negative response.

The results up to this point suggested that the participants were exhibiting a slight leaning towards the successful adoption of 3D Printing technology. A far more conclusive set of responses however was received for the final question relating to diffusion theory, which was the final primary component, *time* (as shown in figure 5.11). Whilst typically this is used as a retrospective tool, to categorise adopters of a technology into groups based on the relative time it took them to adopt, here it is used as a speculative projection. The responses were overwhelmingly positive, with every participant believing they will one day have a 3D printer in their home. A little over half of the participants (65 in total) saw this occurring within the next five years, and all participants expected to have a 3D Printer in their home by 2040. Whilst the first three primary indicators that point towards the successful diffusion of 3D Printing technology into society are far from conclusive, the final indicator provides a very positive attitude towards it being successful.

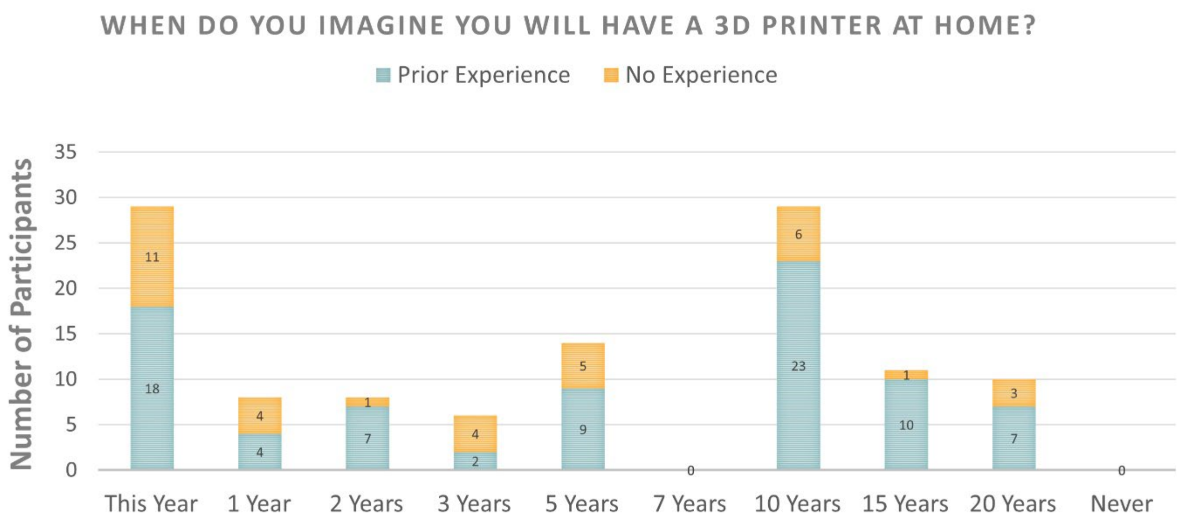
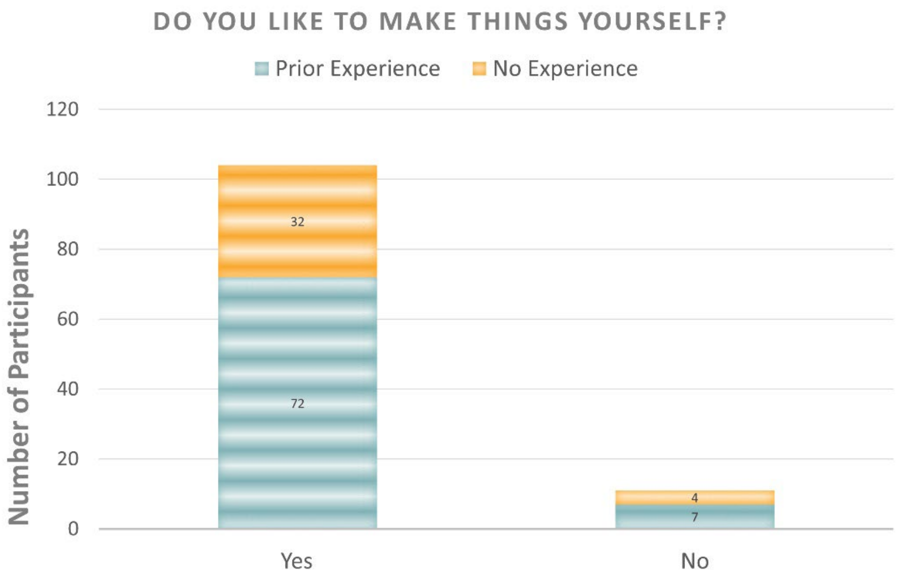


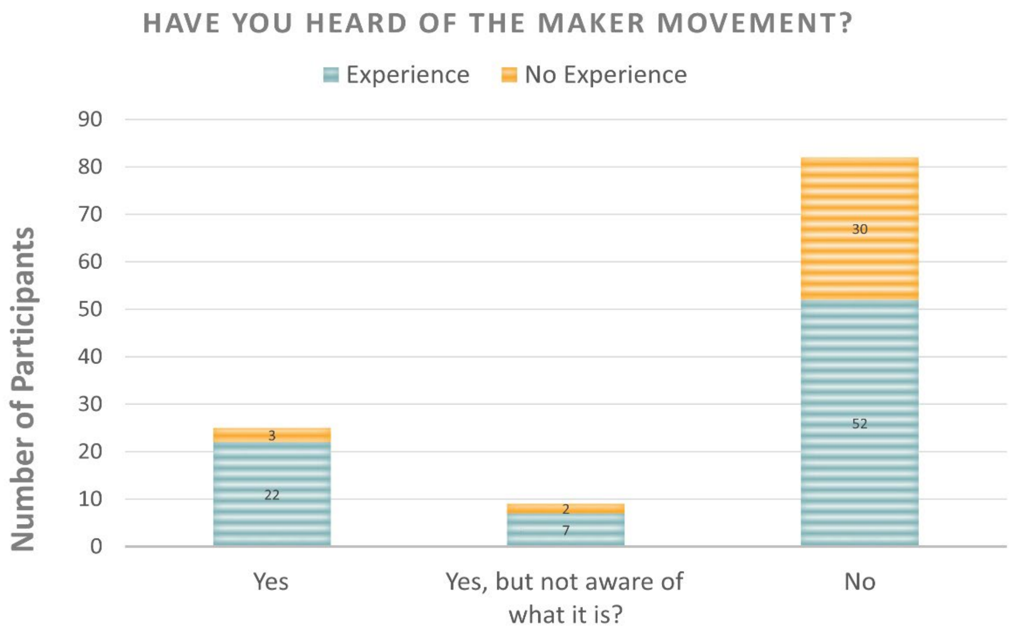
Figure 5.11 Graph showing the results relating to time – These results indicate that the vast majority of participant expect to have a 3D Printer in their home within a decade. This also indicates once again that experience with the technology is not influencing people hard one way or the other in the attitude towards the technology.

5.3.3 The Maker Movement

In addition to those already discussed, there were three additional questions which relate to *communication channels.* These questions were included to ascertain how many participants were aware of the *maker movement*. A clear majority of participants said that they did indeed like to make things themselves, though this is perhaps to be expected, considering that this data gathering session primarily took place at a science and art festival, and then several art and design schools. What was less expected however was their response to the two follow up questions, 'Have you heard of the Maker Movement?' and 'would you call yourself a Maker?'. These results were far from expected, and whilst the *maker movement* may not be a household phrase, the responses shown in figure 5.12 are far below what was anticipated. Despite the high numbers who responded positively when asked if they liked to make things, and the locations that this information gathering was taking place, there was very little awareness of the maker movement. With so few participants being aware of the maker movement, it is understandable that few of them would call themselves a maker.

These results suggest that whilst most of the communication channels were shown be effective, the maker movement, which is very much involved with the promotion and technical development of consumer 3D Printing, has yet to become a mainstream group.





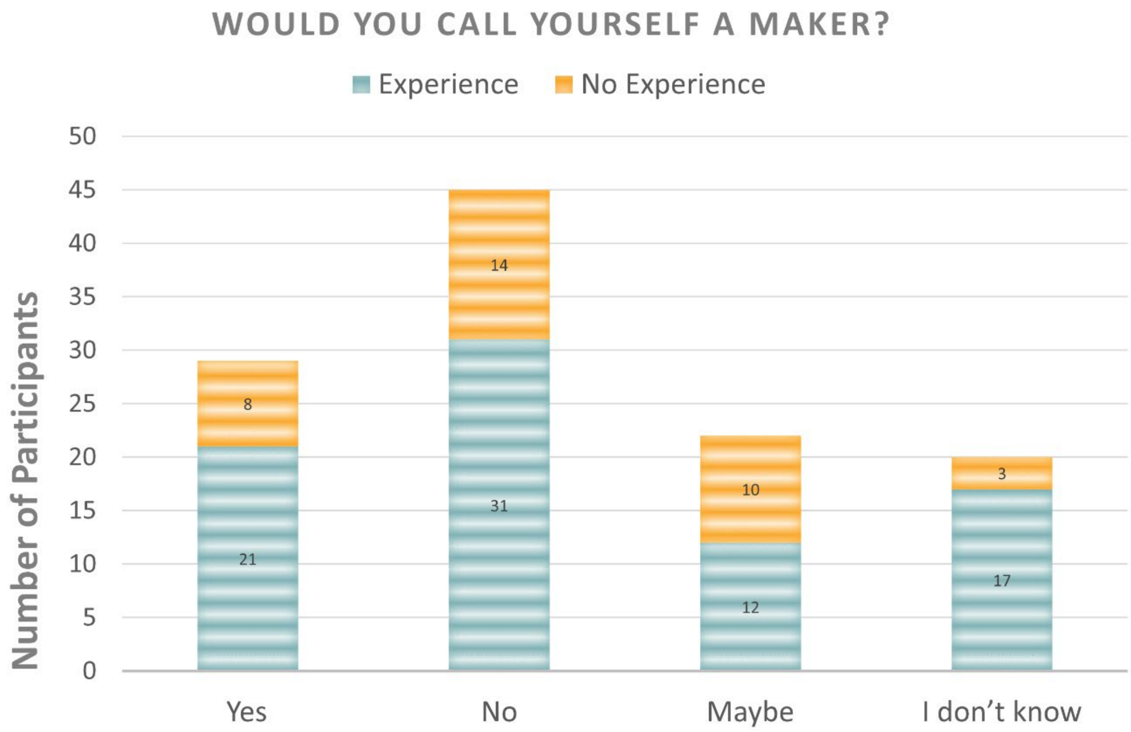
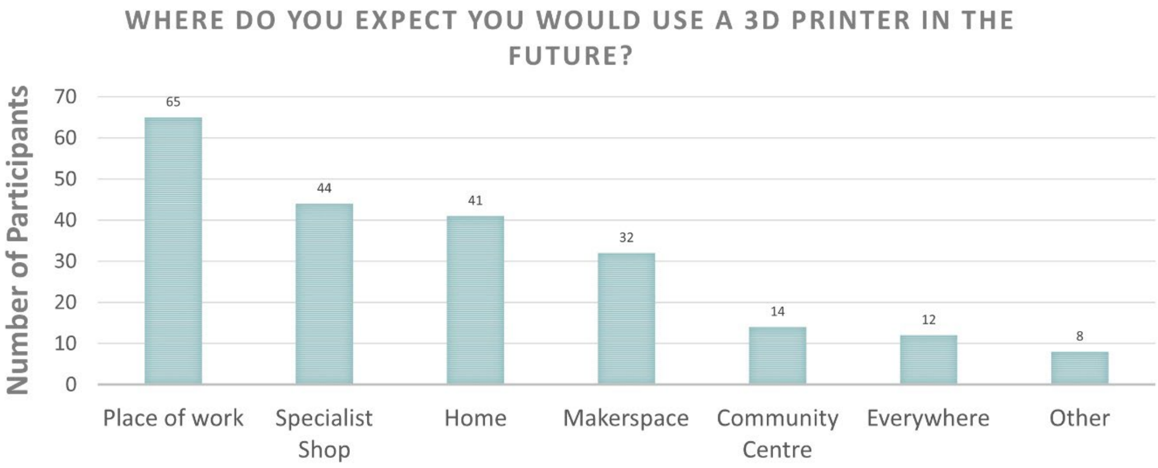


Figure 5.12 Graphs showing results relating to communication channels *in relation to the* maker movement – *Considering the high volume of participants who responded positively to the first of these three questions, it was expected that there would be more positive responses for the two subsequent questions. This indicates that whilst 3D Printing and the maker movement may have a strong relationship, for those outside of this world, the* maker movement *isn't necessarily visible.*

5.3.4 Expected Technology Use

The final series of questions, concerned with the participants expectations and anticipations of 3D Printing technology, generally confirm the findings from Data gathering session One. The location participants most expected to use 3D Printing in the future was their *place of work*, closely followed by *specialist shops*, *homes* and *maker spaces*. These were also amongst the most popular responses for a similar line of questioning during Data gathering session One, the main difference being that previously *home* was the most popular response. These were consistently the most popular responses however, with very few selecting an alternative location to those which had been provided previously. When questioned on where (if at all) the participants would locate a 3D printer within their home, very few felt that they would not allow one in their home. The most popular responses were the *garage*, closely followed by *study*. The results for both these questions are shown below in figure 5.13.



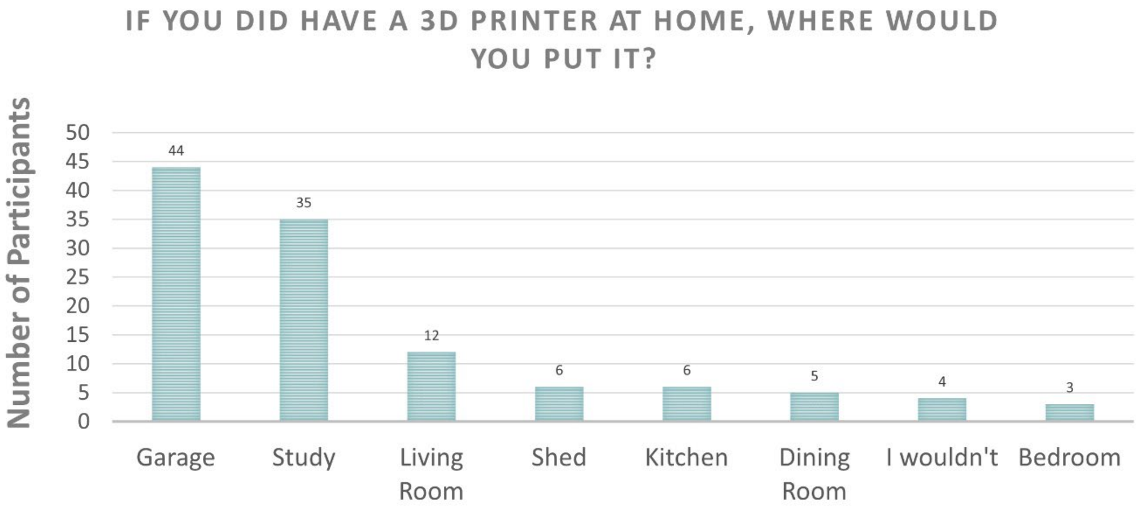


Figure 5.13 Graphs showing the results from two questions asked as a follow up to those from data gathering session one – These questions were influenced greatly by the experience of data gathering session one and were included as a way of validating the previous findings. Though the responses from this second data gathering session do differ somewhat from the first, this is only when considering the numbers for each response. The most noticeable difference was that during this data gathering session, the home was not the most popular location for where participants expected to use a 3D Printer, though it was still in the top three so remains a popular choice. As such, the follow up question which focused on proposing a location within the home where a 3D Printer would be placed, still seems a reasonable query.

Similarly, when participants were asked which material's they expected to be able to print with, once again the results confirmed the findings from data gathering session one. Things did begin to deviate however, when participants were questioned on what they expected to use 3D Printing for. During Data gathering session One the participants were asked similar questions, but they were prompted to consider the *largest* and *most expensive* things they thought they would use 3D printing for. Without these 'nudges', the participants responses in this second data gathering session were more restrained and much more in line with the current capabilities of the technology. Though the participants always had the freedom of choice, the 'nudges' to consider size and cost clearly had a large impact on how they perceived use cases for the technology (Thaler and Sunstein, 2008).

This question was not posed as a multiple choice, but instead open to any response. The results shown below in figure 5.14 are the most popular responses and show that there are indeed shared expectations and anticipations that 3D Printing technology will take on certain roles.

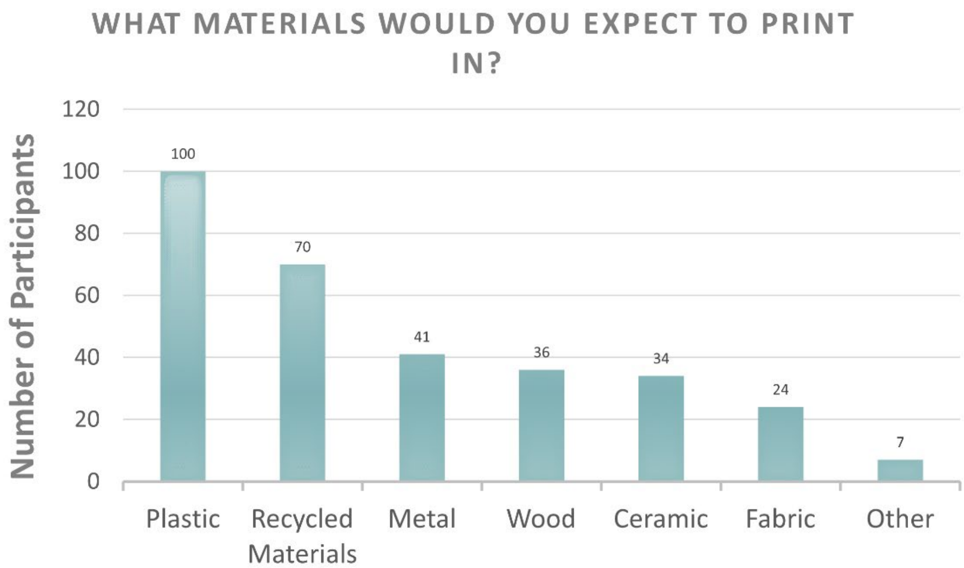


Figure 5.14 Graph showing the results from a follow up question from data gathering session one – Once again, the findings from this second data gathering session confirm those of the first, when considering the range of materials that participants expected to be able to print with. The expected use cases for 3D Printing technology however are extremely different indeed. Without the prompt to consider extremes, such as cost and size, the responses are of a far more restrained, and far more realistic expectation of this technologies use.

5.4 Discussing the Findings

The results from this second data gathering session were not as overwhelmingly optimistic or positive as those from Data gathering session One. One possible reason for this is the nature of the questions themselves, being far less speculative and much more grounded. This change in approach was done to gather more granular information, that was missing from the first set of data. Whilst less fantastical or imaginative in their responses, the participants of this second data gathering session confirmed that 3D Printing is a technology that people do expect will make its way into their everyday lives. Whilst this is the case however, there are quite a few contradictions in these findings. For example, when asked to consider if having a 3D Printer in their home would be useful, the results showed that whilst the majority were positive, many were neutral positive rather than emphatically so. This contrasts with the results from the question 'When do you imagine you will have a 3D Printer in the home?' which had an overwhelmingly positive response, with many foreseeing this occurring within the year and for many it would certainly happen within the coming decade. So, it is fair to say that whilst participants were convinced that they would own a 3D printer someday soon, they were less convinced or aware of its possible usefulness. It is worth acknowledging that this could be due to the design of this research activity, considering that far fewer of the questions were concerned with 3D printing outputs when compared to the questions from data gathering session one.

Looking at this contradiction through the critical lenses, it could be explained that this demonstrates the differences between a technology's adoption and its diffusion. Adoption is when an individual makes the decision to implement an innovation based on their knowledge or persuasion of others within a social group. Diffusion on the other hand is the process by which the innovation is spread amongst the members of different social systems over time. Whilst the diffusion, awareness of 3D Printing and its perceived potential benefits are seemingly widespread, its adoption is not yet assured. However, this provides a purely technocentric explanation. Looking at this same contradiction through a social futures lens could point to a future whereby 3D printers become so mundane and ubiquitous that every household has one, but they are rarely used, much like many appliances that litter people's homes.

Looking at these results through the lens of Rogers' five stages of technology adoption (Rogers, 2003), it seems to suggest that 3D Printing has achieved stages one, two and three, which are *awareness, persuasion* and *decision*. It is the fourth stage, *implementation* (which is perhaps the most difficult to overcome) which has yet to be achieved. This is perhaps unsurprising considering that over half of the participants (60 in total) did not know where they could buy or rent a 3D printer, and even more participants (65 in total) did not know anybody who already owns a 3D printer. This is further confirmation that the *trialability* of this technology could be improved. If we instead use the *Theory of Planned Behaviour* (Ajzen, 1985) as a critical lens for these results, we can speculate on the participants intentions and behaviour. The first determinate to consider is *attitude toward behaviour*, which for 3D Printing is the participants effective evaluation of its benefits. Whilst the results do suggest that the overall attitude is a positive one, this is not convincingly so, with the most popular responses being neutral to positive neutral. The second determinate to consider is *subjective norm*, which in this context would be peer influence to use 3D Printing technology. This is where it was anticipated that the role of the maker movement would be an important one. This proved not to be the case, with relatively few participants being aware of this at all. It would therefore seem that it is the (what diffusion theory refers to as) *communication channels,* that are taking on the role that the maker movement was anticipated to be performing. The results showed that the mainstream media, alongside word of mouth, are effective channels at promoting this technology. The final determinate to consider is *perceived behavioural control*, which is the perceived ease or difficulty of using a new technology. Again, the results suggest that whilst there is a leaning towards a positive attitude, this is presently a tentative one at best.

5.4.1 Summary of Findings

The picture that this second data gathering session paints is a far less ambitious future with 3D printing, when compared to data gathering session one. However, whilst less optimistic, the scenario was relatively similar in that almost everybody expects to own and make use of 3D printing on a very regular basis. The was once again an expectation for the ability to print in a broad range of materials, beyond what is currently available, and that this technology would be widely accessible. Interestingly, despite every participant expecting to have a 3D printer in their own home sometime in the next two decades, the expectation for where they would use this technology was more likely to be at their place of work or a specialist shop.

5.5 Conclusion

The decision was made to design this second round of wide information gathering in a more conventional way, based on the experience of Data gathering session One. Regarding the format of this data gathering session, the questionnaire approach certainly simplified the process of data coding and analysis, when compared to Data gathering session One. However, this second data gathering session was noticeably missing the rich conversations that had taken place around the activity board during data gathering session one, as previously it had not been appreciated how much the research activity from data gathering session one itself had elicited these discussions, rather it was considered that the exhibition environment had played a bigger role. In retrospect this might seem obvious, considering that a questionnaire is for the most part a solitary activity, however, the question board had also been intended to be completed individually. Suffice to say that this is another lesson to be learnt regarding assumptions based on previous experiences. Future data gathering sessions should therefore be designed as stand-alone activities that are not reliant on factors outside of the researcher’s control. However, whilst in this instance the number of participants was lesser than had initially been hoped for, the data gathered was still adequate for the needs of this research.

The data, when viewed through the critical lenses suggests that at present the attitude towards the adoption of 3D Printing is neutral with a slight lean toward positive. Though none of these critical lenses provides a complete understanding of these results and what they mean, this is to be expected, as an individual's opinions concerning the adoption of technology are highly complex and malleable. The findings of this second data gathering session, for the most part, align with the findings from the first. Though it is important to acknowledge that this will likely be due to the design of this research and perhaps more so, the types of participants who contributed to this research, being that they have already indicated that they are interested in technology, science and making, considering the venues that this research took place. Whilst these participants are neither the 'Innovators', nor 'Early Adopters', they could be considered the 'Early Majority' who play an important role in the diffusion process (Rogers, 2003).

Whilst there seems to be enthusiasm for 3D Printing, with the responses all point to an expectation that 3D Printing will make it into the home environment, the participants' anticipated uses for it are far from clear. Seemingly contradictory responses were also provided in Data gathering session One, so this once again confirms the complex nature of understanding technology adoption.

The main differences between the findings of Data gathering session One and Two relate to the level of excitement and enthusiasm for 3D Printing. In Data gathering session One, the open nature of the questions encouraged participants to use their imagination more so, and as a result a great deal of the responses were fantastical in nature and likely highly unachievable, even in a speculated future. The questions posed in this second data gathering session, whilst influenced by the findings from the first, were far more targeted and focused, relating much more closely to the determining factors as described by adoption and diffusion theories. This seems a likely reason, along with the change in format, that there was a slightly diminished enthusiasm for 3D Printing, throughout this second data gathering session, when compared with that of the first. Whilst less fanciful in nature, these findings provide a useful contribution to understanding the meaning and values that are shaping attitudes towards 3D printing technology.

6.0 Data Gathering Session Three: Interviews

6.1 Introduction

This chapter describes the third data gathering session, designed to reveal how 3D printing technology is currently being used by the public. It begins by explaining the aims and scope of this data gathering session followed by an explanation of the process of designing the research activity. This starts with a brief introduction to the context that this research is working within, by explaining the concepts of Open-Source Design and Manufacturing. The design of this data gathering session is then discussed, along with an explanation of the decided format and research participants.

The aim of this research is to develop a method for the creation of graphic social futures as a tool to help guide people in thinking about futures. It is for this reason that the future visions are being informed by the people, to describe future scenarios that are representative of their expectations, not those of corporations. To produce these relatable future visions this research is using the method of backcasting (as discussed in Chapter Three), which requires three main things. The first is a preferable future to strive towards, this has been the function of data gathering sessions one and two (Chapters Four and Five), which have revealed information to describe this. The findings from these have painted a picture of a future world in which 3D printing is widespread and accessible and provides an explanation of how people expect to make use of this technology. The critical lenses help to understand how the technology will become adopted and diffused, which helps to track the trajectory and understand how this could become a reality. For example, how likely it is for 3D printing to become a domesticated product found in most households or remain as a specialist device which is accessed on the high street or community space, if at all.

The second is an understanding of the present, which is the focus of this third data gathering session. In much the same way that the initial data gathering sessions sought to engage with the public to drive these futures, a similar approach was taken for understanding the present. This time targeting the managers and technicians who run makerspaces, to uncover how people at present engage with 3D printing. This data gathering session would also allow these participants to share their own experiences of engaging with 3D printing technology and their thoughts on its future.

The third is a chosen interstitial point between the present and the preferable future, in order to work out what steps would need to be taken in order to make this chosen future a reality. This will be the subject of subsequent chapters, which will explain this process as it has been applied to this research.

The findings so far have been primarily informed by participants who have had very limited, or even no practical experience of using 3D printing technology. The role of Data gathering session Three was therefore to understand how members of the public currently use this technology in practice, as a contrast to how they expect or anticipate using it in the future.

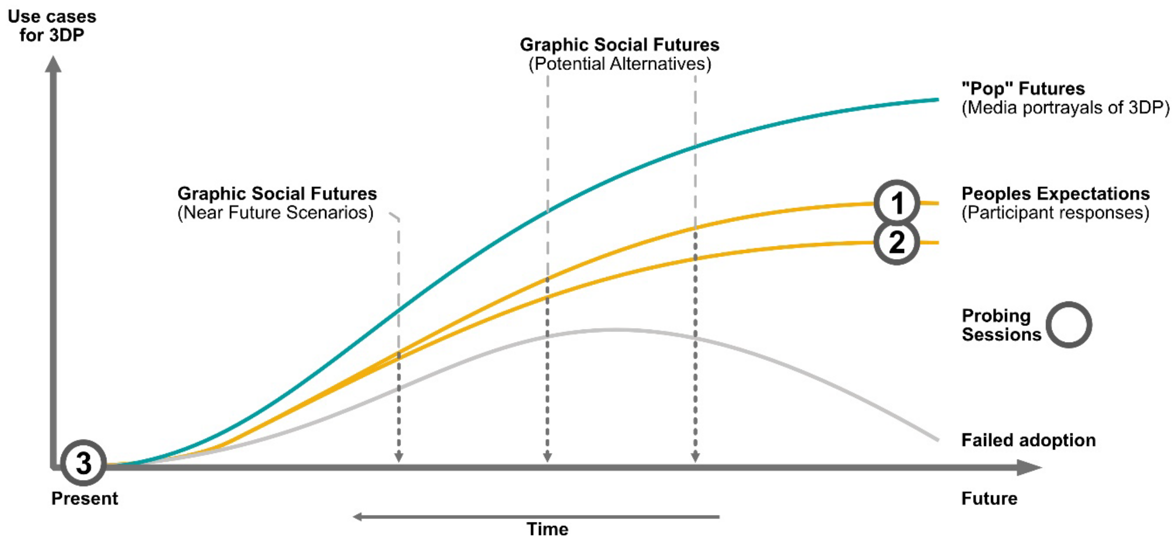


Figure 6.1 Diagram explaining how the backcasting method is being used with the data gathering sessions – This diagram of the backcasting method indicates how the data gathering sessions are positioned to provide the information required to describe the present for 3D printing use by the public and their future expectations for this technology. The graphic social futures will present scenarios which show alternative imaginaries which could possibly manifest along the way to delivering the preferable future.

6.2 Open-Source Design and Manufacturing

There is no shortage of research literature concerned with understanding the impact of consumer 3D printing technology. Much of this focuses on the new ways of design and production that digital fabrication technology has enabled, which is referred to as *Peer-Production*. Peer-Production or *Mass Collaboration* is a way of producing goods and services that rely on self-organising communities of varying sizes and skills, to work towards a shared outcome, creating what Benkler (2006) describes as new technological-economic feasibility spaces for social practice. Peer production is therefore a new form of production, based on what Bauwens (2009: para.5) calls "permission-less self-aggregation around the creation of common value". As has already been discussed in Chapter Two, the maker movement has an affinity with open-source approaches to design and manufacturing, as such an overview is provided here to provide further background and context to Data Gathering Session Three.

Peer-production is a process that takes full advantage of, and in many ways is only made possible by the collaborative possibilities afforded by the internet. Another major conditional requirement for the success of peer-production is the voluntary contribution of knowledge. This begins with the emergence of the "contributive economy, in which new technological affordances create the possibility of open and transparent production systems, thereby creating a new economic logic that is not based on labour creating capital, but on contributors creating commons" (Banerji and Paranjape, 2016: p.194). Because digital content can be made widely available and be freely replicated and/or downloaded once it has been produced, it is therefore not scarce and so operates outside the supply and demand market. The internet enables the required coordination of these individuals and small groups on a global scale, without the need for control hierarchies or a physical location (Bauwens, 2011).

The development of software by peer-production is often referred to as open-source, which is a decentralised software-development model that encourages open collaboration and began as a direct response to the limitations of proprietary code (Levine and Prietula, 2014). Open-source promotes universal access via an open-source or free license to a products design or blueprint and allows universal redistribution (Lakhani and Von Hippel, 2003; Gerber *et al.*, 2010)ppel, 2003; Gerber et al., 2010). Open-source generally refers to a computer program or online content, whereby the source-code has been made available to the public. The success of this process led to the emergence of open-design and open-manufacturing (Raasch *et al.*, 2009).

Whilst open-source is concerned with immaterial/digital outputs that can be produced and distributed freely, open-manufacturing is concerned with the production of physical goods, where there are inevitably costs involved (Bauwens, 2009). However, anything that needs to be produced, must first be designed, and modelling a three-dimensional object is now in most instances a software-based process, often dependant on collaborative minds. This affords new potentials for collaboration between open-design communities and new modes of manufacturing (Wittbrodt et al., 2013; Prendeville et al., 2016). Rather than one design community working with one company, as is the case in most co-design and co-creation projects, you can instead have a global community of designers and makers, but also a global network of manufacturers that can download the design and produce things much more locally (Kostakis, Bauwens and Niaros, 2015; Prendeville et al., 2016).

It has traditionally been the producers' model that was the dominant mode of innovation, whereby the most important innovations would originate from the producers and be supplied by the goods and services they sold. Today however these conditions have changed, as explored in figure 6.2, costs associated with designing products have decreased and the ability to communicate with other users has improved. Consumers are now able create innovations for a market of one, take part in peer-to-peer collaborations or work with other producers/manufacturers (Moreau *et al.*, 2010).

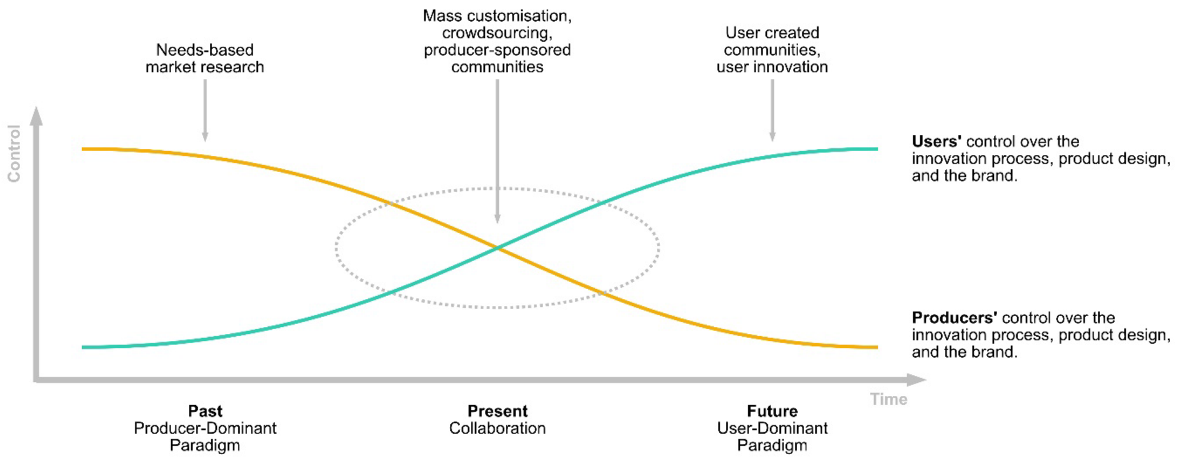


Figure 6.2 Adapted version of the Innovation Continuum diagram by Page Moreau et al., 2010 *(redrawn by author) –This diagram describes the shift from producer control of innovation to user control. The orange line represents the diminishing control of the Producers over time, in contrast to the green line which represents the increasing control of users over time. This shift is in part made possible due to the reduction in costs associated with designing products and improved communication methods. Note that this is not a claim that all innovation is collaborative at present, merely that the balance of control is shifting.*

In much the same way that there is a great deal of hype in the media concerning 3D printing technology, research concerned with the maker movement is also often more concerned with the potential for this technology, than the present reality. This research, however, is concerned with understanding how 3D printing technology is being used by individual members of the public, as opposed to entrepreneurs or tech start-ups. This is certainly an area that is currently lacking research, and it is for this reason that Data gathering session Three targeted four makerspaces across Lancashire, to discuss the current use cases for 3D printing that they witness on a weekly basis.

6.3 Arranging the Interviews

Each of the four makerspaces invited to take part in this research are located within the Northwest of England. At each location, the manager and or technician was interviewed, with questions that related to their makerspace and their own personal experiences and thoughts on 3D Printing technology. When contact had originally been made with the makerspaces and individual interviewees, an explanation of the interview process was provided, along with background information on this research. Each participant was provided with a participant information form and were given the opportunity to ask for further clarification or explanation about anything they were unsure of. Each individual was then provided with a consent form to complete prior to taking part in the process.

To be consistent with the previous two data gathering sessions, the questions posed to the interview participants align with those factors which make up the critical lenses. However, this chapter is more concerned with the discussions that took place and the insights offered by these individuals who are in something of a unique position, being that they are often introducing new users to 3D printing technology for the first time. Each makerspace has a range of equipment, ranging from entry level consumer models, through to prosumer and sometimes industrial models. Each of the interviews was carried out anonymously, this was deemed necessary to have an open and honest conversation regarding the makerspace's users. In hindsight this was perhaps unnecessary, considering that they are not sharing any personal information. Regardless of this, as the interviews were anonymised, the Makerspaces and their participants will be referred to in the following way:

Makerspace One	*[M1]*	*Interview One*	*[I1]*
		Interview Two	*[I2]*
		Interview Three	*[I3]*
		Interview Four	*[I4]*
Makerspace Two	*[M2]*	*Interview Five*	*[I5]*
Makerspace Three	*[M3]*	*Interview Six*	*[I6]*
Makerspace Four	*[M4]*	*Interview Seven*	*[I7]*

Each interview was carried out as a guided discussion, using a fixed set of questions as a guide (as indicated in figure 6.3, but allowing the conversation to flow naturally. As a result, not all the questions asked in these discussions were asked in the same order for every participant, and in some instances, questions were skipped, if the answer had already been provided, or the subject covered earlier in the discussion.

Lab Questions:

1. Can you please briefly describe your role and your Makerspace, e.g. what equipment/specialisations do you offer?
2. How frequently is 3D Printing used in this lab?
3. Is 3DP used as much as you expected it to be?
4. What would you say is the most common use for 3DP in the lab?
5. Are users generally impressed or disappointed with the reality of 3DP?
6. What materials do people most use/want or expect to use?

Personal Questions:

7. When did you first become aware of 3D Printing?
8. When did you first use a 3D Printer and what was that experience like?
9. Do you use 3DP for your own personal projects? If so, how frequently and for what types of things?
10. Other than here, where have you used a 3D Printer?
11. Is a 3D Printer something you would consider having in your home?
12. What do you think the barriers are to using this technology at present?
13. What would encourage you to use 3D Printing technology in your home?
14. Have you used any technology that you think is similar or comparable to 3DP?
15. How easy do you think 3D Printing is? 1 being very easy and 10 being very difficult?
16. Where would you say 3DP is on the Gartner Hype Cycle?
17. What do you believe are the perceived limits to 3DP technology?
18. What do you think genuine progression of this technology will be and what is just a 'fad'?
19. Any other comments, thoughts or insights on anything we have discussed?

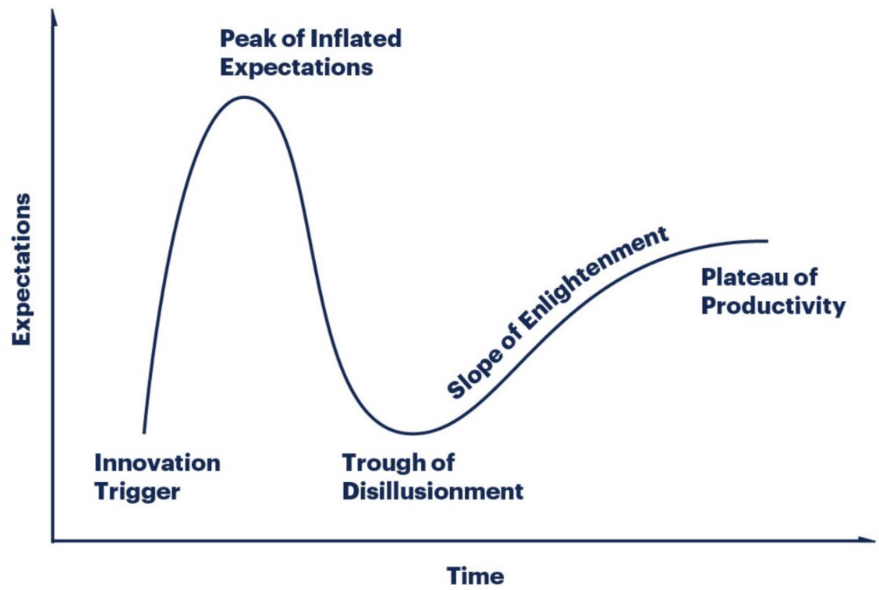


Figure 6.3 The set of questions used as a guide for each of the interviews. – These were used to help steer the conversation and ensure that each participant was posed the same set of questions. In some instances, it was

not necessary to answer all the questions as the discussion concerning one question could reveal the answer to multiple questions.

To maintain a narrative through this chapter, the response from each participant, for each question will be discussed, followed by a summary conclusion explaining how these findings can be understood in relation to the previous data gathering session findings, using the critical lenses. To aid in the discovery of insights within this data, the transcriptions from three and a half hours of interviews were entered into NVivo, a qualitative data analysis tool. This analysis was carried out alongside a manual analysis of the transcriptions, to uncover deeper research insights and confirm those which this research had already identified. The key findings will be discussed here.

6.4 Part One - Makerspace Questions

The first set of questions related directly to the *makerspace* and the interview participants role within it. These questions were intended to encourage a discourse on how people use these spaces, with a particular focus on, but not limited to, the existing use cases for 3D printing technology. This was also an opportunity to discover how those who are part of the maker movement describe these spaces and the work that they do, to see how this compares to the existing research on this subject.

The interviewees were first asked to briefly describe their makerspace and their role, along with being encouraged to explain any specialisations that their space offered. This question was included to provide context for the responses that follow and to consider the highly individual nature of these typology of spaces. Interviewees One, Two, Three and Four are all conducted with participants from the same *makerspace,* which whilst having close ties to the council, is ultimately an independent company. Interviewees Five, Six and Seven are discussing their own makerspaces respectively, each of which is connected to, or associated with a large university.

6.4.1 Introductions

The interviews began with each interviewee describing their makerspace and the role that they play in its day to day running. (M1) began with interviewee one (I1) who is the Manager of the FabLab, who explained that:

> Our makerspace is a community interest company (CIC), we try to turn people into makers and makers into entrepreneurs. The first part, people into makers usually comes through our weekend, Fridays and Saturdays we are open to the public for free for personal projects, for a lot of people this is their first experience of these machines, the software, what it means to be a maker and the maker movement. Because most people don't know that this sort of subset of society exists, and then we turn makers into entrepreneurs.

Interviewee two (I2) is the Director of M1, describing how:

> The Fablab side of this is part of a bigger facility which is all focused around entrepreneurship, but the kind of technology we offer in the lab space is very similar to the basic Fablab model but with a few bits on top of that… [W]e do quite a full range, and we do have larger, more industrial equipment than most FabLabs, such as the large industrial 3D Printer and the large laser cutter.

Interviewee three (I3) is the Technician of M1 who explained that:

> In real terms that means that I take care of the Machines, make sure that people can use them safely and creatively and I write and run workshops. I also do commercial jobs as well, and people pay us to do prototyping and development. And then the public also come in, so I teach them, we say for free, but they also pay for materials, those are the two different ways that the place works.

Interviewee four (I4) from Makerspace one described themself as a volunteer who just helps-out when they can. Interviewee Five (I5) is the Creative Technical Demonstrator of *makerspace* two (M2) which they explained as:

> We are demonstrating the technology, but we are also the supervisors, and we are managing the facilities, so I look after the makerspace. The technologies we have got are based around the idea of Computer Aided Design and Computer Aided Manufacture, workshop tools for prototyping, subtractive and additive manufacturing and then classic craft…

Interviewee six (I6) is the Manager of makerspace three (M3) which:

> Is a relatively new department, I have been here for two years and that was when the department started. The idea is that we can offer a space in which the students can come in and learn to design and make things using digital fabrication equipment. So that's quite a standard model, I think the key differentiator is that it is not for a specific subject area. Often you will have technical labs which are associated with just engineering or just science or just art and design, but the makerspace is a cross-campus, cross-university facility, so anyone can come in and use it and they don't need to be from a particular discipline or have certain knowledge.

Interviewee seven (I7) is a Technical Officer at a specialist Print Lab (M4) who describes their role as:

> Supporting the academics, the students, and the researchers in everything that they do. My role here specifically is looking after the 60 something 3D Printers that we have here. We have eight different types of technology that I oversee, I assist from the concept of an idea all the way through to post processing, and that is for students, academics, researchers and also industry… We have industry coming in here as well, across faculty anyone who wants to use my services and the services here, I help them.

Having visited these spaces, the scope and scale differs greatly, each offering different sets of equipment and focusing on different specialisations, they do however share the common aim of introducing people to, and promoting the use of digital fabrication equipment, especially 3D printing.

6.4.2 Current Uses for 3D Printing

This data gathering session was approached as a series of guided conversations, rather than adhering to a strict interview format. Because of this informal approach, the conversation was allowed to flow naturally, often resulting in multiple topics being discussed in response to a single question. Therefore, it was not always necessary to ask all the questions, as it was common for the conversation sparked by one question to also provide the answer to a follow up question. Here the responses will be discussed in the order as originally written, to better allow for the comparison of responses from the different makerspaces.

Having been asked to introduce themselves and describe their role and makerspace, the following question was concerned with the frequency that 3D Printing technology is used in their makerspace. When discussing M1, I1 and I2 explained that in terms of commercial work, it was the technology that they had the most demand for, but there was far less demand from their public users. Though it is worth noting that I3 stated that whilst the FDM machines may only be running a few hours during open access, this was consistently so.

It was a different tale for M2, with I5 explaining that the 3D printers are used almost daily, and around submission periods for the university, there can be a queue of up to a week to use one of the machines. When the machines aren’t booked to be used, they themselves carry out experiments and demonstrations. It was a similar story for I6, so much so that M3 has invested in what they referred to as the Print Hive, a collection of 14 different models of 3D Printers, which are all used daily.

Things are a little different for I7 in M4, as they are a specialist Print Lab and have over sixty 3D printers at their disposal. These machines are used every single day, with some even being run over the weekend if a long build time is required.

The follow up question was concerned with understanding how this level of usage compared to their expectations for the technology, or if they had indeed had any expectations for it at all. In the Case of M1, I1 and I3 thought that their expectations had been met, due to the relatively high barrier to entry that 3D modelling creates for beginners to 3D printing technology. I2 however had expected a far greater uptake than had been the case, despite procuring three different types of 3D Printing technologies, each aimed at specific levels of users, all had fallen short of their anticipated level of use.

I4 confessed that their enthusiasm for new technology does sometimes distort things, but that 3D printing was being used as much as they had hoped for. This optimism was shared by I5 who explained that as their users typically already have the ability to use and understand CAD, they don't experience that as a barrier to entry.

I6 has had an altogether different experience in M4, stating that "sometimes, honestly it's used too much. I think that 3D printing is seen sometimes by students, more often than not, as a get out of jail free card…". The obvious difference here is that M4, unlike the others, does not offer any other equipment, so there is no option to demonstrate how a different technology might be a more suitable option for the task at hand. I6 goes on to further describe how in their opinion, the users:

> Really should have gone to a DIY shop and bought some rod and some wood and we should have made this properly, but instead we have got a sort of get out of jail free card with a 3D Print. And obviously with a 3D Print you just hit a button and it comes out. So honestly, I think the applications of 3D Printing […] should be limited to things that are designed for additive and not otherwise.

The next question was interested in understanding what the current primary uses for 3D printing are. I1, I2 and I3 all agreed that in M1 the most common use for 3D printing is prototyping parts, closely followed by enclosures, jigs and fixtures. This focus on the prototyping stages meant there was far less demand for the high-end, high-quality printing technology that they had available, but also that there was less interest in the 3D Printing of novelty items.

I5 explained that due to the primary users of M2 being arts and media students, there is very little thought given to the mechanical properties of the artefacts being created with the 3D printers, instead they are much more concerned with creating props and visual representations of their character designs. Arguably this could also be considered prototyping, as it is still being used as a means to test the design in a physical form, regardless of its intended end use.

Both I6 and I7 said that in their labs it was also rapid prototyping which was the most common use for 3D Printing technology. Though it is worth noting that I6 made the distinction that often these were for custom designs, so it was an exploitation of the technology to make unique forms that was the driver for the users electing to use the technology, rather than prototyping for a product which would later be mass produced in another means.

Despite the many different 3D printing technologies that these spaces offer, it is worth noting that in every instance, it was the FDM machines, printing in PLA or ABS plastics that were the most in demand. The next question was concerned with understanding if users were generally impressed or disappointed with the reality of 3D Printing?

I1 thought that users were impressed because it allows them to access things that there is no other way of doing so, such as a printed 3D scan of themselves. They also made the point that wrapped up into the whole process of 3D Printing is the experience of watching it grow, it offers a level of involvement. Though they did also make the point that it can also be disappointing for those who are not necessarily interested in the process of making, as the results do not match those that we are used to as consumers and there are misconceptions regarding the technology.

I2 felt that people were still “gobsmacked” and “amazed” by the results that come out of a 3D Printer, noting that as they have been in the industry for many years, they view this all as “a bit old hat now”, there is still a large proportion of the population that still haven’t seen 3D printing in action, so when the do experience it and see what it can do, they are “more than impressed”. They felt that this could be because they may have seen some of the entry level or home-made 3D printers and the stringy results that they produce, so when they do then see something that results from an industrial printer, people realise the quality that they are capable of.

I3 echoed these thoughts and pointed out that even users who come from a manufacturing background may not have already experienced 3D Printing. They did express however that many people are expecting the results to be a ‘finished piece’ rather than the lower prototyping quality, which is the majority of the printing that they actually do.

I5 thought that users were impressed with the results but pointed out several misconceptions that they regularly come across. The first being ease of use, explaining that most users aren’t aware that during the design process they need to consider tolerances, overhangs and supports etc. they are instead expecting to take a design straight from their 3D modelling software and print it. The second factor is time, users are frequently shocked by the duration of prints because they aren’t contextualising the process in comparison to other process of manufacturing. They explained that when showing users the results that are possible they are extremely impressed, however this enthusiasm diminishes somewhat when they explain the process in its entirety.

I6 once again raised the point that whilst users are impressed with the standard of the prints they receive, users often misinterpret the meaning of rapid prototyping and expect results in minutes and seconds, as opposed to hours or days.

I7 explained that users were mostly impressed and happy with the final quality. They thought that it was likely that people who have had some prior experience with 3D printing technology have only used hobbyist quality machines which only produce low-quality prints. So, when compared to the high- quality cutting edge technology that M4 has, there is quite the difference. This was followed by the now familiar sentiment that whilst users are ultimately impressed with 3D printing, users are mostly unimpressed by the timescales.

The final question relating specifically to the interviewee's experiences in their respective *makerspaces*, was what materials do people most use or expect to use? I1 explained that sometimes, as new users typically know very little about the technology, they expect to be able to print in anything. Whereas all the other interviewees immediately responded that ABS and PLA are the most common materials to be used, with this being primarily attributed to the materials relatively low cost.

These conversations confirmed the experiences and observations of how users typically engage with 3D Printing in these types of spaces. One opinion shared and repeated by several of the interviewees was the level of influence that the staff and volunteers of these spaces have on the use of the technology in these spaces. This was something that had already been anticipated and would be explored further in the second series of questions.

This first series of research questions was inspired by personal experiences with fabrication equipment and how it had transformed personal practices. The second series of questions would provide an opportunity to discover if this same level of enthusiasm for this technology was shared, and how the interviewees saw the future of 3D printing unfolding.

6.4.3 Summary

The responses from these interviews indicate that the use of 3D printing technology is well established by commercial users of the spaces but is less so by the public. Though there was steady use by members of the public, it was reported that this was often in ways that were considered by the technicians to be ill-suited to 3D printing. This was especially true for students who had been directed to use 3D printing as part of their workflow, but perhaps did not sufficiently understand the best way to exploit this technology.

The most common use case for 3D printing that the interviewees witnessed was the production of prototypes and jigs, indicating that commercial users used this technology as just one stage of a larger process, and for public users it was the creation of bespoke objects. Interviewees observed that 3D printing certainly captured the imagination of public users, with lots of interest directed towards 3D printing devices, however, the resulting objects did not always live up to the public's expectations, especially regarding the quality of the prints, when compared to an injection moulded part and the speed of the process, being that it takes hours rather than minutes to manufacture.

6.5 Part Two – Personal Questions

Through studying and analysing the interviewees responses, several key themes, ideas, and thoughts were emerging, and at this point further analysis was carried out using NVivo, a qualitative data analysis application. The results from this corroborated the initial findings and highlighted several additional themes. The discussion that follows presents each of the key themes that emerged from this series of interviews.

6.5.1 Empowerment and Community

The first is a combination of two themes, which in the context of makerspaces could be considered intrinsically linked, these are *Empowerment* and *Community*. The theme of Empowerment is perhaps unsurprising given the ethos of these makerspaces. This idea of empowerment related to both the aims of the spaces themselves and the potential afforded by 3D printing technology. At the heart of the makerspace concept is the idea that users develop their skills until they are producing goods of a high quality and begin getting commissioned work. The hope is that this then increases a user's confidence until they are ready to start their own business, "…in terms of impact, that's the best thing that we could offer" [I1].

With an increasing number of CAD programs targeting users with little to no prior experience, 3D printing could offer a very accessible route to experimenting with art and technology. And as the interviewee I7 discussed, “my 9-year-old daughter who is completely computer illiterate was shown how to use *TinkerCAD* and within 4 hours was printing things for people, it’s piqued her interest.”

An interesting point that I3 raised was how much of a stark contrast to the status quo of consumerism 3D printing presents, being that individuals are ultimately responsible for what they create. They did however believe that this process of creating things for yourself was relatively easy, assuming you have access to the internet, as there you will find plenty of support for using the printers if required and there are sites where you can download thousands of models, which can be “useful parts for inside a washing machine, or they can be your Pikachu’s…” They also explained that whilst it could be thought of as a waste to use this technology to just make little models of cartoon characters that we don’t see a use for, that can be just as important as it is still providing a new user with an introduction to that technology[11].

Others commented on the democratisation of manufacturing and the impact of being able to try things out in a relaxed, playful environment, which is what makerspaces are all about. This leads on to the next theme to be discussed, Community. The first makerspace visited for this research is a CIC and as such there is a strong social element to this FabLab. Others, although working at what are ultimately private makerspaces, expressed their belief that

> [T]hese technologies should be used by a community, not just by individuals… and this is what the whole makerspace movement is about anyway. It’s about the community, it’s about the people, that’s what makes a makerspace, not the gear, but the people in it.

I5 stated that if they didn’t have daily access to 3D printing, they would certainly have one in their home, though they were a strident advocate of community spaces for engaging with technology and

[11] Whilst much more could be said about the relationship between CAD and 3D printing, the points included here are limited to only those that were raised during the interviews. In some respects, CAD modelling and 3D printing are intrinsically linked as an appropriate 3D model is a prerequisite for any 3D print. However, there are also many people who use regularly use 3D printing who bypass the need to create their own models by purchasing pre-prepared 3D print files from specialist online markets.

as such really believe in the idea of *makerspaces*, rather than everybody having their own personal machines. They were extremely enthusiastic about 3D printing technology, they did however point out that they saw this as a single tool in the larger process of making something and it certainly isn't "a magic box that will make my thing for me… it will do what you tell it to do and if you tell it to do something stupid or rubbish then it will produce something that is rubbish."

Their final comments espoused the benefits of community ownership and enabling the access of these technologies to everybody in society. So, whilst they believe that in the coming future everybody will indeed have access to 3D Printing technology, they believe this will be occurring in shared community spaces. Their closing statement was:

> I am hoping these things will drive that more, because that is the way I see society, or I want to see society going in that direction, I want to see people having community again and this, these tools can create that and bring back that whole making and craft idea.

6.5.2 Potential

The next theme is *Potential*, again this is perhaps predictable to some extent as 3D Printing is an emerging technology and as such there is much it has yet to achieve. Some of these comments related to the makerspaces themselves, others were concerned with 3D Printing itself. In a similar vein to the discussions around Community, there were several mentions of the opportunity for further engagement, whether this be the creation of new, easily accessible tools for digital creation or the development of low-cost, entry-level machines. There was also a great deal of enthusiasm for new materials and the potential impact that this could have. The main hope was for multi-material and metal printing to become available at the prosumer/consumer level of the market. As interviewee I6 described it:

> Because we are still quite limited to what strong materials we can have, what flexible materials we can have, rubber would be a big one, as those functional materials get better and better, that's when were gonna see the real application of it, because then you can

print you know a whole product and all the functional materials within it, if that could be printed on one printer.

I3 vividly recalled how they first stumbled across 3D Printing, explaining that they estimate they were about 14 years old and came upon a *YouTube* video about a company called *Contour Crafting* (a term now synonymous with 3D printing with concrete) who were using it to create disaster relief housing. I3 expressed that straight away they realised there was a great deal of potential for this technology. Whilst I6 had dismissed the idea of having a 3D printer in the home, they did go on to explain that if the costs, material selection and speed of fabrication was improved they did "think it could be a tool that would be part of a normal sort of workshop or shed type facility that you might have at home, because it is a very versatile tool."

In a similar vein to comments made by *I5, I6* also explained they believe that to get the best out of 3D printing technology, it does need other tools to sit alongside it. Though they were quick to admit that they themselves are a little biased in saying this, being that they are running a *makerspace*.

6.5.3 Sustainability

The next theme is *Sustainability,* which whilst closely aligned with *Potential*, was discussed in several different contexts and so is deserving of a separate section. The first suggestion is that with access to 3D printing, people could repair or even upcycle their devices rather than simply disposing of them. The ability to download designs and manufacture them on site also drastically reduces the carbon footprint of the product by eliminating transportation costs. There was a clear acceptance that in some ways 3D Printing could be considered as part of the problem, being that the printers are typically producing "lots of plastic widgets that are contributing to landfill" [I6]. One even wondered if "perhaps people printing out plastic crap is offset by the fact they no longer need to throw away their vacuum cleaner etc" [I1]. There was however also the offer of a solution, with many commenting on their use of fully recycled filament and even the opportunity to bring this in house, with the creation of recycling machines and filament extruders.

When discussing the future of 3D printing with I1, they focused on the ecological benefits that this technology could deliver. Whilst there is currently a concerted effort towards the reduction of use, they pointed out that maybe the ability to repair plastic components would reduce waste being sent to landfill, though they were very aware that this would require companies to see some benefit in allowing people to recycle or repair their machines. Their final comment was "It's a horrible thought though, this 3D Printing revolution that we are waiting for in people's homes may never occur, in some respects."[12]

6.5.4 Expectations

The penultimate theme for discussion is *Expectations*. The themes discussed so far have been concerned with the aspirations for the makerspaces or 3D printing technology, but this research was also concerned with understanding how the technology is currently being used. 3D printing is often colloquially referred to as rapid prototyping, and as it transpires, this is exactly the primary use for this technology in every space that was visited. This use case ranged from jigs, enclosures and product prototypes to film props and character production. Though it is worth noting that this was predominantly discussed in relation to the commercial work that was done, rather than the use by public users. As such, it was also interesting to hear what the interviewees thought the experience was like for new users, and what their personal expectations for the future of 3D printing were.

Again, there was a consensus across the different makerspaces, the expectations from 3D printing are extremely high. The most frequent comment was that users are expecting to 3D print a finished piece, rather than it just being one step in a longer process. It was also mentioned that "[people] don't know what to expect, they think we should be able to print in anything, so we get questions like, can we print in wood? Because they don't know, they don't have preconceptions. Expectations are just through the roof" [I1].

[12] In a similar manner to the discussions concerning 3D printing and CAD, there is much that could be explored in relation to the sustainability of 3D printing. However, the discussion here is limited to those points that were raised and discussed by the interviewees.

Another comment which was mentioned time and time again was the expectation around the speed of 3D printing. Whilst users were typically impressed with the quality of the prints, they often balked at the timescale, discussed by I6 as, "people come in with the understanding of it being Rapid Prototyping and thinking that something is going to come together in minutes and seconds, so it is a bit of a blow when they are told its going to be overnight, or days to produce a part." Another way in which users' expectations did match reality is the reliability of the machines, users expect to be able to just push a button and the machine will produce whatever they want, unfortunately for some "the output is disappointing because it is not as good as what we are used to as consumers" [I1]. It was also pointed out that the devices can be rather loud and some processes, such as selective laser sintering of resin (SLA), can be quite messy.

There are two additional factors that I2 believes will aid in the adoption of 3D Printing, which are the development of more functional materials and improved 3D scanning technology. The development of functional materials as "then you can print you know a whole product and all the functional materials within it", also improved 3D scanning technology, as at present it "is still quite specialist and laborious" but could be used in lieu of learning 3D modelling processes. Once again one of the perceived benefits of this technology was its potential for repairing broken parts, because if we can "reproduce those plastic parts at a low cost and very easily then that should hopefully reduce the number of things going to landfill and do a lot more recycling and upcycling of things" [I2].

I6 expected that there is still a lot to come from 3D Printing, but that people are starting to realise that it is not the solution to all manufacturing. Whilst there are some fantastic examples of parts production made on location as and when required, reducing carbon emissions and altering the product life cycle, that is not to say it is the solution to every problem. They went on to explain that they are also increasingly aware that users are printing lots of plastic widgets that may ultimately find their way to landfill, so have started using only companies that produce recycled filaments based in the North of England. They also explained that:

> …further development looking into how the 3D Printing material can be reused is an area that I think will be kind more considered in the future, rather than just 3D printing little widgets and then not caring about where they go or how to dispose of them properly [I6].

6.5.5 Barriers and Limitations

The final topic for discussion is *Barriers* and *Limitations*, as this was an opportunity to find out the experts' opinions, based on their experience introducing new users to 3D printing. There was once again several topics of discussion which were experiences repeated across the different makerspaces. The first Barrier to 3D printing was 3D modelling, or to be more specific, the need to produce a 3D model in the first instance. This was considered a substantial barrier to entry as even with many years of experience, some interviewees expressed how they "still find some shapes quite difficult to model" [I1]. They also went on to describe the attitude towards 3D printing as "the whole Henry Ford thing of, if I had asked people what they wanted they would have said a faster horse, as opposed to a car. So that's a big barrier, the fact that people don't know that they want it or could need it".

For those who do have a use for 3D printing however, there is still the issue of cost, "because if I wanted one that was decent, we are still talking £2000, so it's still a luxury really" [I2]. If users do make the decision to purchase such a device, there were considered to be further barriers too, mainly reliability and presently being somewhat unsuitable for a domestic environment. Whilst I1 regularly uses 3D printing in their home, they expressed a major drawback is the noise that the consumer level machines produce, evidencing a noise complaint they received from neighbours in their building, stating "[w]hen I had a printer at home, we had noise complaints, it's a very squeaky one, I bought dampeners, but it still sounds like a dial-up modem" [I1]. They also pointed out that using this technology in an enclosed space can produce fumes, which when combined with the noise was causing their flatmate to have migraines, which is quite a barrier to its use. When asked how easy they thought 3D Printing was, they pointed out that personally they found it to be relatively straight forwards, however, in their experience the users to the *makerspace* perceived it to be very difficult.

I2 described how they considered a barrier to 3D printing being adopted in the home at present was cost, as a device that was capable of producing the quality and reliability they would be interested in is currently priced around £2000, which is “still a little bit of a luxury really”. When discussing the perceived ease or difficulty of use for 3D Printing, I2 explained how they considered the answer to come in two parts. Firstly, there is the 3D printing itself, which they described as being the easiest process in the lab, as it is “basically a case of just loading a model and press play.” The second part however is what they considered to be the big hurdle of 3D Printing, producing the 3D model in the first place. They explained that they believe this is the biggest barrier to people’s adoption of 3D Printing technology, as 3D modelling is something that takes “a lot of time and understanding to get the hang of and its quite a complicated process and it takes a lot of practice, so for people to have the confidence to produce a 3D model that they can then print takes them quite a while to get there…”.

I3 considered the main barrier to adoption to be the perceived complexity of getting the final product into your hand. They did expand upon this by explaining that they believed if users were aware “that they could get free software, watch free *YouTube* videos, and buy a £200-£300 machine and then get a £30 spool of material” then there would be much greater levels of adoption, but they thought that at present there is a fear of the unknown.

In terms of Limitations, the discussions produced a great many suggestions. The first being the quality of finish that you get from a 3D printer, with other machines in the labs producing far better outputs. There is also a limitation on the materials (depending on which 3DP technology is being used), some are very difficult to reliably print with and others have poor mechanical properties. There is also the issue of the reliability of the machines themselves, 3D Printers are notoriously “inconsistent and prone to errors with calibration and can require constant attention” [I6]. The disappointment at the speed and build size of typical 3D Printers was also discussed, but there was one statement relating to people perceptions, that resonated especially well with the findings from both Data gathering sessions One and Two. "People see it as a 'Black box that will make my thing for me' but you have to put effort in, it will do what you tell it to do, and if you tell it to do something stupid or rubbish it will produce something stupid and rubbish" [I5].

I4 could not imagine themselves having a 3D printer in the home as they have yet to see the need or want for it and were happy with the access they have in *makerspaces* and at university, though they might reconsider it if they increasingly need to physically visualise project work outside of a CAD environment. Their main criticisms of the technology at present were centred around the mechanical properties of 3D printed parts being disappointing, speculating that "it's never going to take off as it is right now" I4.

6.5.8 The Hype Cycle

The final question posed to each of the participants can be discussed collectively. They were each shown a blank diagram of the *Gartner Hype Cycle* (Gartner Inc, 2016) and asked to indicate where along the path to adoption they considered 3D printing to currently be. The hype cycle is a tool developed by *Gartner* for understanding the promise of an emerging technology, to decide if, and when, to adopt said technology. The *Hype Cycle* uses five key phases to describe a technology's life cycle, these are:

- **Innovation Trigger**: This is where early proof of concepts trigger significant publicity, despite no usable product yet existing.
- **Peak of Inflated Expectation**: Early publicity produces a slew of success stories – and a score of failures.
- **Trough of Disillusionment**: Interest wanes as experiments and implementations with the technology fail to deliver. This is where the technologies 'shake out' or fail.

- **Slope of Enlightenment**: More instances of how technology can be of benefit become more widely understood.
- **Plateau of Productivity**: The Mainstream adoption of the technology occurs.

Despite being one of the most prominent and influential models for advising on technology investment, it faces a number of criticisms, primarily that it is not a scientific method due to "methodological flaws and procedural inconsistencies" (Steinert and Leifer, 2010). Despite these criticisms (and others) this method was chosen as it provides a clear visual representation which is easy to understand, something which was important for an interview scenario. Additionally, this research is not necessarily concerned with gathering empirical data, it is instead more interested in the opinions of the interview participants and developing a better understanding of their perspective on this subject, therefore the method was considered appropriate for this purpose. This diagram is also commonly used in industry reports, such as the *Additive manufacturing trend report 2021* (Roberts, 2021) as shown in figure 6.4.

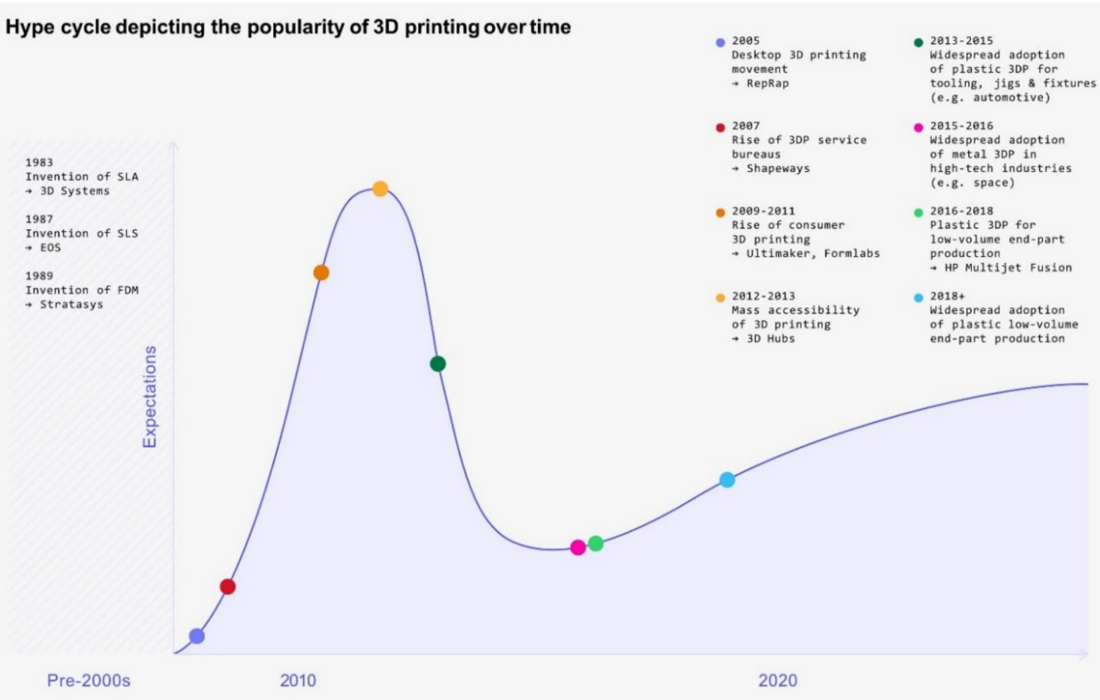


Figure 6.4 The Hype Cycle diagram for 3D printing as of 2020, 3D Hubs, 2021 *– The 3D Hubs annual additive manufacturing trend report charts how they consider the industry to have evolved in 2020. Each of the coloured*

dots represents a major progression in the development and adoption of 3D printing technology. It is important to note that this diagram includes both advances in consumer grade and industrial grade devices.

The diagram below this [Fig 6.5], shows where each of the interviewees thought that 3D Printing technology currently sits on the *Gartner Hype Cycle*. Considering that the interviews took place in 2018, three years prior to the 3D Hubs report being published, it is interesting to see the majority of participants agreed with the trajectory for the adoption of 3D printing technology. With the exception of I1 and I7, all of the interviewees were of a similar opinion, positioning 3D printing at present just after the *Trough of Disillusionment*, somewhere at the early stages of the *Slope of Enlightenment*. I2 explained their decision as:

> I think that in the mid-teens we went into the peak of expectations, especially around about 2013 2014, which is where we hit that enormous massive PR Hype, I think then probably towards 2016, 2017 we were either at or very close to the trough of disillusionment, so I think probably we are just about, […] coming out of the trough of disillusionment, and we are just starting to see, not necessarily the mass public, but certainly a lot of industry people are starting to see the real future applications and the real useful applications… So, we are coming up that slope now.

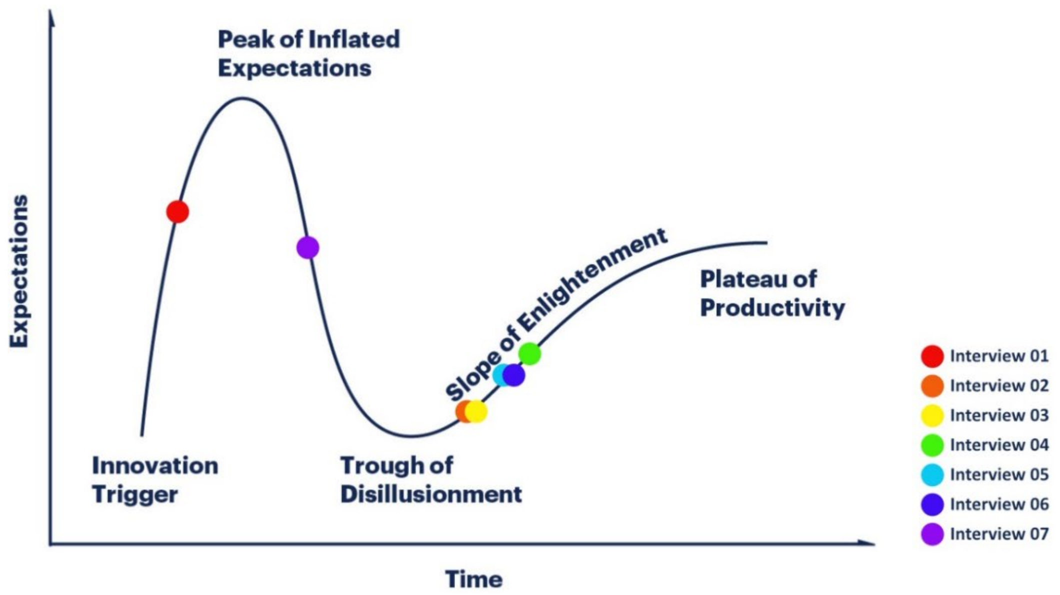


Figure 6.5 The Hype Cycle diagram for 3D printing as completed by the interviewees as of 2019 – Each of the interviewees was shown this diagram of the Gartner Hype Cycle (Gartner Inc, 2016) *and asked to place a dot where they think 3D Printing currently sits.*

The two outliers, I1 and I7 also offered explanations for their decisions. I1 explained:

> I think we are going to go through this process a number of times, before most people use 3D printing. I think it's going to be repeated, so there will be points when it's like, cool we can do all this stuff, and then we realise the actual reality might be less good, so we plateau for that technology, but then the technology improves, and it happens again. Whether this current cycle gets it (3D printing) into everyone's homes, I'm not sure. There will be a plateau, but it might not be in homes, it might be in businesses and start up facilities and similar.

I7 considered there to be too much expectation from this technology, recalling that:

> "In the old bureau where I used to work, […], you would get people phoning in, "I have a 1954 shotgun and it requires a new stock, if I sent you a picture of it, could you 3D Print it?" And it's not just the shape of it, they wanted the walnut effect and everything, but it's like no, it doesn't quite work like that. Expectations are just through the roof, but I think we have got to the point where we are just realising that it's not going to do everything, but we are not quite disillusioned yet either."

These results from this exercise suggests that the majority of the interviewees perceive 3D Printing to be well established and is well on its way to becoming a fully adopted technology by those who have already engaged with it. Though this further contributes to the idea that whilst this technology is being successfully adopted across several channels, it is yet to become widely adopted by the general public.

6.6 Summary of Findings

This third data gathering session presents two complimentary, but very different ideas for the future with 3D printing. The first, rather expectantly, is one in which local makerspaces encourage people to embrace their creative side and experiment with technology and art. This could be tapping into popular culture to make replica props or cosplay or attempting to produce replacement parts for broken devices around the home. The idea of democratised manufacturing and a relaxed playful and supportive environment for learning is at the heart of the maker community.

The second idea to emerge is the acceptance that perhaps not everybody has the inclination to try 3D printing themselves, and so perhaps the technology thrives, but as a service. This is a service that some makerspaces already offer to commercial enterprises, perhaps this is also how people are more likely to engage with 3D printing technology in this manner. There was also a common theme throughout all of this, which is the use of 3D printing technology to improve our ability to repair and or replace parts, lengthening the life cycle of our products and contributing to a more circular economy with greatly reduced waste.

6.7 Conclusion

Each of the interviewees expressed an extremely positive attitude towards 3D printing technology and saw the potential for it to play an increased role in the future. However, this positive attitude was accompanied by several caveats. Primarily that for 3D Printing to achieve its true potential, it must be used alongside other technology, it cannot replace an entire workshop. The second caveat centred on the user’s ability to produce suitable 3D models, something which is necessary for any successful print. Whilst it was pointed out that there are many new and free to use 3D modelling tools aimed at absolute beginners, it is still a skill that most people have not required before.

These views are obviously somewhat biased, considering that each of the interviewees is employed in a makerspace, however, their reasoning for expressing the benefits of theses spaces seemed to be legitimately held beliefs. Whilst it could be considered a “…horrible thought [that this] 3D Printing revolution that we are waiting for in people's homes may never occur..." [I1], these interviewees expressed their belief that the benefits of this emerging technology will be achieved, albeit not necessarily in the same manner that is often promoted by "pop" futures.

The findings from this data gathering session have provided the foundation for understanding the *present* state of consumer 3D printing. The insights revealed by these interviews provide a necessary contrast to the overly ambitious expectations that have been revealed through Data gathering sessions One and Two. This research now has findings that can inform and describe both a far-off speculative future, and the existing reality of 3D printing in the 'present', the two components necessary for backcasting. The process of how this information and the process of backcasting will be used to inform a series of graphic social futures, will be discussed in the following chapter.

7.0 A Speculative Triptych

7.1 Chapter Outline

Designers use visualisations and graphic techniques to give voice to their and other viewpoints, using graphic displays as a means to empower social and political actions (DiSalvo, 2009; Kim and DiSalvo, 2010). This chapter describes the process of how the findings from Data gathering sessions One, Two and Three were used to inform the creation of three graphic social futures. This begins with a discussion explaining how the three scenarios were decided upon, which is followed by an explanation of how the future mundane approach to futures has inspired the style of the illustrated future visions. Following this is an explanation of how the visual hooks have been selected, and to fully explain the process of taking the findings from the three prior data gathering sessions (as discussed in Chapters Four, Five and Six), each illustration is discussed, and the inclusion of each major detail, and how this was informed by the data gathering sessions is explained.

7.2 Socially Constructing Alternative Imaginaries

From the outset the intention was to produce a series of illustrated speculative future visions, informed by the findings from the three prior data gathering sessions. What had not been decided upon was the number of illustrated scenarios that would be produced. Having analysed each of the data gathering sessions, three distinctly different, but complimentary scenarios emerged, which will be described in this chapter. These were influenced by the most frequently anticipated locations for future engagement with 3D printing technology, which were Everywhere/Specialist Shops, Community Makerspaces and a Home environment. Whilst each of the data gathering sessions did align more with one scenario more so than the others, the findings were not handled in a siloed manner, and so the ideas from each of the data gathering sessions can be shared and used to influence multiple scenarios.

The first step was to combine the different data sets to get an overall understanding of what the findings suggested. The two key factors that would be most influential drivers for the scenarios was the location that people expected to engage with 3D printing technology, followed by what the expected use cases would be. Appropriately locating these scenarios was an important first step, when considering that "[i]t is through *place* that we are able to assemble different elements to compose an image of our future, not an ambiguous space" (Dunn, 2021, p.304). Figure 7.1 shows that most people expected to engage with 3D printing at home, followed by a makerspace, place of work and then specialist shops, with some expecting that they could use it everywhere. Having considered these results and the conversations and discussions that occurred around each of the data gathering sessions, three different scenarios would be required to appropriately showcase the range of ideas. The process behind how this decision was made will now be explained.

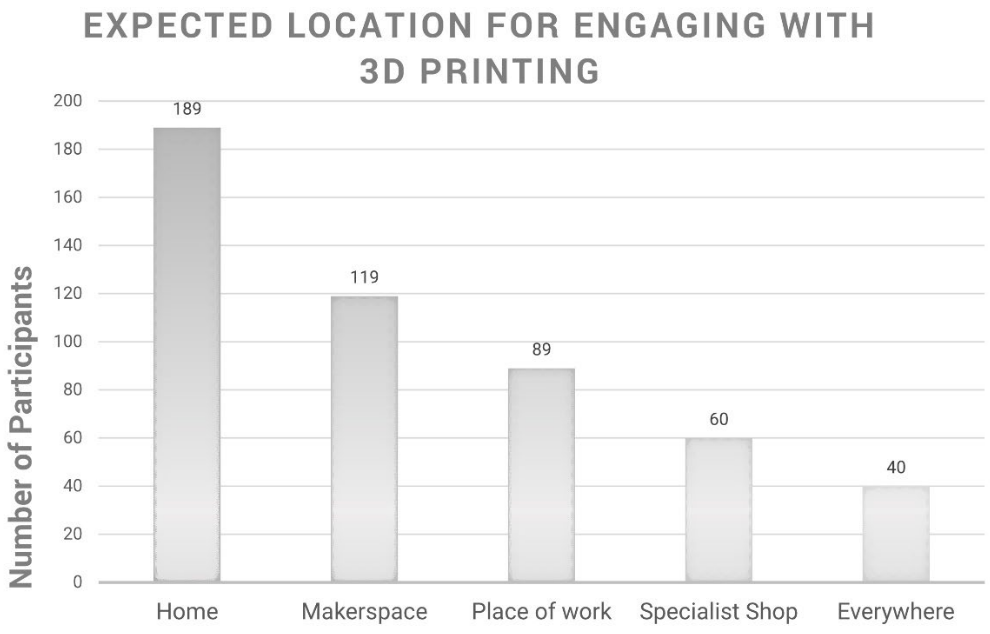


Figure 7.1 Graph showing the expected locations for engaging with 3D printing – These are the combined results from data gathering session one and two, showing the locations where people most expect to use 3D printing technology.

The first scenario would need to be a domestic environment, as across each of the data gathering sessions there was an extremely high level of expectation for people to have 3D printing accessible within their home. Referring to the results from data gathering session two, figure 5.12 shows that if found within the home, it would likely be placed in the garage or study. The second scenario would be a makerspace, as this was not only the subject of discussion (as would be expected) in data gathering session three, but this idea also emerged through data gathering sessions one and two as a likely location to engage with this technology. For the third scenario, the data suggests a place of work, however, the anecdotal evidence suggests that this was not for personal use, rather they expected to use it as part of their job. Therefore, this scenario will not be explored, and will be replaced by a streetscape. This not only provides the opportunity to explore the idea of specialist shops which exploit 3D printing technology, but also the idea of being able to engage with this technology everywhere, which was also a common expectation.

With the context for three scenarios decided upon, the next step was to consider the types of artefacts and other use cases that people expected they would use 3D printing for. This would provide the detail required for designing an appropriate range of visual hooks. Figure 7.2 shows the most anticipated use cases for 3D printing technology from data gathering sessions one and two. This makes evident the wide range of uses that people are expecting this technology to cater for. Considering the range of uses, not all of them will be explicitly shown within the scenarios, instead there will be details that imply that these types of uses are occurring. These three different scenarios range greatly in scale and scope, therefore they will each include those details and visual hooks that are most appropriate to the scenario, so as to maintain the suspension of disbelief.

In summary, three scenarios were described by the data gathering sessions; these were a *Streetscape*, which represents 3D printing being available anywhere and everywhere, a *Makerspace*, which also represents community spaces and specialist shops etc., and a *Domestic Workshop*, representing 3D printing in the home. These three illustrated scenarios form a *Futures Triptych*, with each illustrated panel representing a different aspect of the same alternative social future.

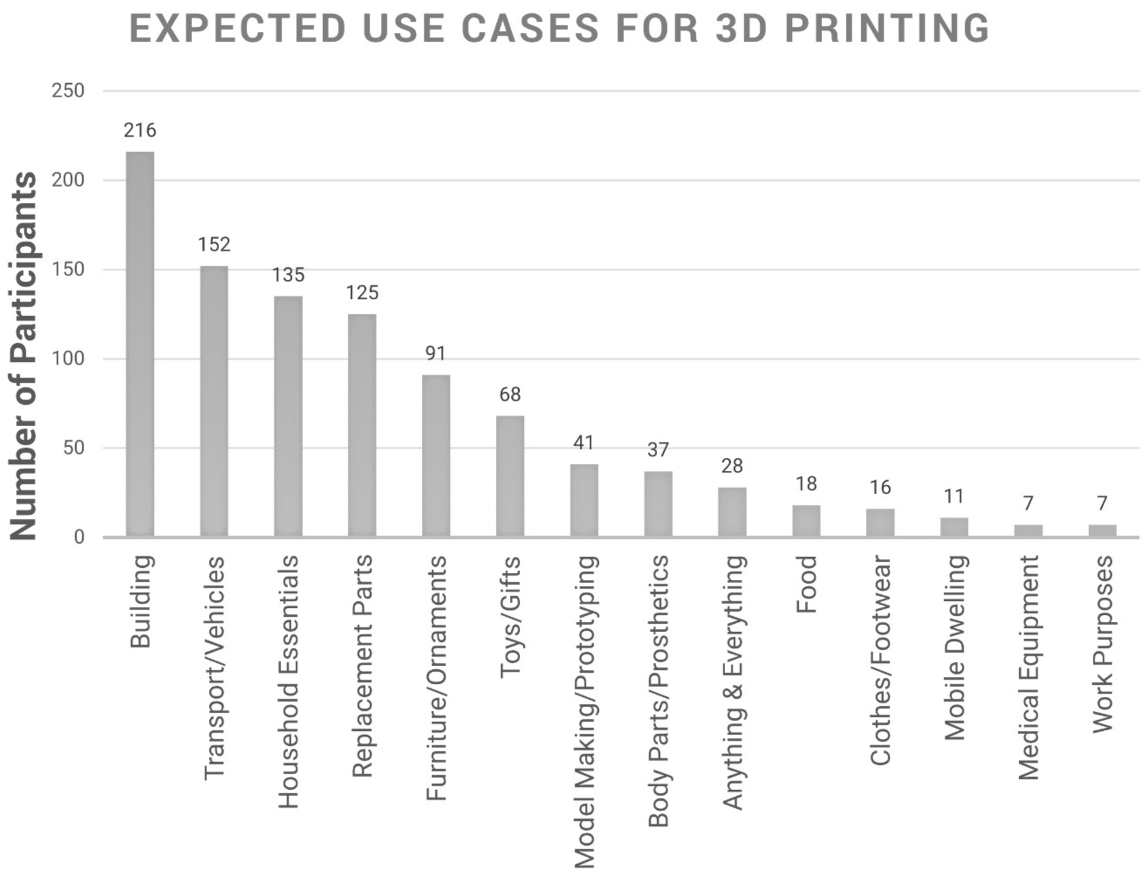


Figure 7.2 The combined results from data gathering session one and two, showing the most expected uses for 3D printing

7.3 The Agency of Visions

Having analysed the findings from each of the data gathering sessions and decided upon the most appropriate scenarios to compose, the next necessary step was to develop an appropriate style for the visualisations. This needed to be easily recognisable as a future speculation, whilst also avoiding the pitfalls of producing frictionless vapourworlds, as discussed in Chapter Two. This is an important consideration when viewed against the growing discourse concerning the role of visualisation in futures studies, as visual communication is amongst the most effective means of informing and engaging with communities (Rose and Willis, 2019; Gaziulusoy and Ryan, 2017a). Much of this discourse is centred around the way in which smart cities are often portrayed, which in a similar manner to corporate visions, “contain powerful agency in how we conceive future urban life” (Dunn and Cureton, 2020a: p.19). As has already been discussed in Chapter Three, this research follows the relatively well-defined approach of design fiction as world building. This method of world building aims to create plausible depictions of near future scenarios, in which todays emerging technologies can be embedded within an everyday domestic situation (Coulton *et al.*, 2019). Design fiction is not an attempt to predict the future, but it does anticipate and speculate near *futures*, it is an alternative to the typical utopian or dystopian approach and is a way to tell stories about alternative and unexpected trajectories. As the *Near Future Laboratory* explained, the “aim is to spark conversations about the near future, check the sanity of visions and uncover hidden perspectives” (Girardin, 2015: para.12).

It is for this reason that this research is influenced by the future mundane approach to *futures*, to create visions which are the antithesis to the more frequently seen, but also more homogenous, banal and benign, visioning projects (Dunn and Cureton, 2020a). When describing what is meant by the *future mundane*, Foster (2013) explains that *science fiction* and industrial design have an influential effect upon one another, with designs impact on science fiction cinema being well documented. Whilst it might be difficult to divorce the two industries, Foster draws the line between these two as being their use of narrative, story and plot. Foster explains that whilst industrial design futures require a story and sometimes even a narrative, they almost never require a plot, whereas science fiction cinema always requires a plot. This is an important distinction as “[p]lots are difficult, complex and involved”, requiring “significant development of character and space, leading to an aesthetic that drives the narrative forward” (ibid., para 4). Unfortunately, as Foster explains, industrial designers have a tendency to reach for “cinematic aesthetics without a plot” when creating future visions, resulting in images and products (such as Fig. 7.3 below) that “invariably seem banal, twee and idealistic to the point of fantasy” (ibid., para 6).

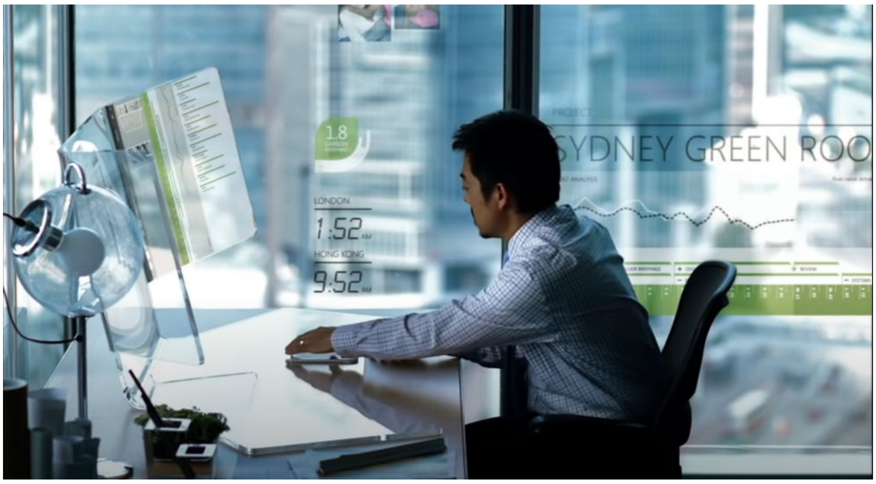


Figure 7.3 Productivity Future Vision (promotional video), Microsoft, 2011 – This still image taken from Microsoft's promotional video is an example of a banal future vision, resulting from industrial design borrowing from what Foster (2013) *describes as the 'cinematic aesthetic' without considering a plot.*

That last point is an important one, as design fiction relies on its ability to suspend an audience's disbelief about change, which means that whilst they may recognise the work as a fiction, the technology or artefacts being presented must still contain a logic if they are to be believed. As such, any visions that could be perceived to be banal, twee or idealistic must be avoided as this would not allow for an audience's suspension of disbelief. The science fiction novelist Ryman (2014) was concerned about the prevalence of, what he saw as fantasy elements within his genre, such as warp drives and cloaking devices, and so introduced the idea of *Mundane Science Fiction*[13].

As has already been discussed in Chapter Three, this approach comprises three major elements which will be using to guide the creation of the three speculative future scenarios, these are:

1. The Future Mundane is filled with background talent
2. The Future Mundane is an accretive space.
3. The Future Mundane is a little bit broken.

[13] This is in no way intended as a criticism of science fiction, it is an attempt to clearly define the difference in the approaches of hard science fiction and pop science fiction, as this is an important distinction for understanding design fiction.

Considering that this research is concerned with presenting alternative social futures, these guiding principles are especially salient. The target audience are not the Hollywood heroes attempting to save the world, they are the ‘man at the bus stop’ or the ‘taxi driver’, trying to quietly enjoy each day. The intention is also not to transport them to a strange new world populated entirely by chromium technology. Much like the world around most of us today, the future will also likely be slightly broken or show signs of repair. One statement by Foster sums up this sentiment well:

> In parallel, we should consider how quickly our 'amazing new innovation' will become a normalized. Once technology finds its way into mass communities it ceases to amaze, ceases to be seen as technology at all, it becomes a regular part of the tapestry of life. (Foster, 2013)

The graphic social futures will intentionally present an audience with scenes from a near future that depict emerging technologies as entrenched and a part of everyday lives, encouraging them to consider what impact it could have on their own lives and to question if they consider this to be a positive or a negative.

7.4 Building Worlds

Another criticism of the current approach to future city visions is that they are “detached from social needs or aspirations” (Dunn and Cureton, 2020a: p.23). This is similar to the discourse in futures studies regarding the notion that these are ‘preferable futures’ for who? (Dunne and Raby, 2013). Current visualisations of future cities also play down the individuality and uniqueness of the places they are illustrating (Valdez *et al.*, 2021), presenting and emphasising a smooth and frictionless future, where the public’s role is often overlooked (Rose, 2017).

Being that the aim is the creation of socially constructed social futures, the next step was to scout for appropriate real-life locations that would serve as backdrops for the graphic social futures. As each of the data gathering sessions had taken place in the North West of England, it was important that the illustrations also be representative of this area, especially considering this would also be the intended audience for the finished visuals. The *future* elements of each composition would be informed by the findings from the data gathering sessions but placed within familiar settings. This approach to creating the compositions was similar to the work of Strange Telemetry*,* for the UK government's Foresight *Future of an Ageing Population* project, which was mentioned in the introduction. There were several key findings from their work that have been considered in this research.

Firstly, their research revealed that there is a wide range of literacy when it comes to *reading* the images, with some participants quickly focusing on particular artefacts which they then used to open up wider discussions. There were, however, also participants who focused on elements of the design which had not been intentionally *placed* or considered, such as whether the layout of space in question was realistic. Therefore, everything included within the future visions must be carefully considered and serve a purpose. Their second finding was a pragmatic one, the importance of displaying the visions at an appropriate scale, as "when using images filled with so many details, particularly those which were text-based (e.g. Shop signs, advertising), it is important to provide artefacts large enough to show all of these details" (Voss et al., 2015b: p.10). Being that each of the speculative visions will be laden with small details, influenced by the earlier data gathering sessions, it was necessary to ensure that these small details are clearly discernible by every participant. This leads to the third finding, "very simple visual cues can push perceptions in one direction or another, such as dark skies or presence of greenery, indicating that for this type of visual discursive work, every small detail matters"(ibid.: p.10). Strange Telemetry also made the point that whilst they had made an early design decision not to include depictions of people in their images, in efforts to avoid the issue of stereotyping, this led to constant criticism from participants who found the scenes to be "empty, unfriendly, and perhaps even under some sinister dystopian control" (ibid.: p.10).

It is also worth noting that the images produced by Strange Telemetry were digitally rendered, which by their own admission is much like the research required to inform them, in that it is a highly time-consuming process. Personal experience of creating virtual images confirms that it is extremely difficult to produce a convincing photorealistic image. Not only does it require a great deal of time and effort, unless it is done to a very high standard, which is problematic as this can require a great deal of computational power, the images often fall somewhere within the *Uncanny Valley*, where things appear almost real, but not quite real enough to be convincing. This was something that this research was very keen to avoid, as this would make it difficult for participants to look beyond the faults and therefore make it unlikely for them to successfully suspend their disbelief. It was initially considered that creating abstract digital renders could avoid this issue, however, it was decided that a more appropriate solution would be hand drawn illustrations. Not only is there a well-established relationship between illustration as a medium and science fiction (Mitchell, 1984), but this would also avoid running into problems concerning the uncanny valley effect which is possible with computer CGI imagery or photorealistic compositions (Voss *et al.*, 2015a). As a medium, illustration also lends itself well to presenting a playful, flexible and approachable scenario (Dunn and Cureton, 2020a). Of course, the medium alone is not sufficient to convey an authentic message, whilst it does have intentionality and agency, there are also examples of visions which have been criticised for using this aesthetic to "camouflage itself amongst positive ecological and people-orientated attributes and messages" (Dunn and Cureton, 2020a: p.23). To avoid imagery that is removed from the complex realities of actual places, Valdez et al.(2021), provide three key lessons for designers of visual communications, which will be used to guide the creation of the graphic social futures. These are:

- Be true to a city, with realistic reference to images of the city.
- Be sure that the portrayal of people represents the diversity of contemporary society.
- Make sure the visuals engage with the people, rather than just wowing them with technology.

7.5 Visual Compositions

The composition and visual style of the images to be presented was an important consideration for this research. The first step taken was to develop the setting for each of the three scenarios. This was achieved primarily through site visits, some of which had occurred during the data gathering sessions, when a visual record of the spaces had been taken, in addition to site visits that occurred after the data had been analysed and the three scenarios had been decided upon. These site visits resulted in a series of photographs that represented the types of spaces that this research had been conducted in and the types of spaces that the findings of this research had suggested.

Having gathered reference material for the different scenario settings the next step was to begin researching experimental and emerging 3D printed products and prototypes that represent the most popular expected and anticipated use cases for 3D printing in the near future. This was primarily carried out by performing internet searches and delving into online community forums for makers and 3D printers. The images gathered ranged from virtual renders through to photographs of physical working prototypes. This process, along with the location scouting, provided all the material needed to begin assembling the compositions.

Each of the scenarios was produced using a vector graphics software program running on a drawing tablet. A vector-based program was chosen as this would allow the artwork to be scalable and offer flexibility in editing or adapting the artworks at a later stage, in an easier fashion when compared to a pixel-based image. Whilst the use of CAD could make it easier to manipulate the reference images that had been collected to present them as projections or multi-point perspectives, it was decided that single point perspective should be used as this is from the viewpoint of an observer, and the aim of these visual scenarios was for the observer to feel as though they are part of the scene.

With the scenes composed as a photomontage in the CAD software, the next stage was to begin the process of rotoscoping and sketching over the guide images. Illustration was chosen as the most suitable method for creating the visuals as this has a longstanding relationship with science fiction images (Mitchell, 1984) and by illustrating over the reference material a unified image would be created. To begin the illustration the photomontage was then drawn over in a similar manner to rotoscoping, which is a technique used by animators to trace over motion picture footage, to create realistic motion. It was considered that this approach, along with the decision to employ single point perspective views, would aid in the viewer putting themselves into the scene.

7.6 Entry Points into the Worlds

Having carried out several visits to local towns in North West England to scout and photograph locations that were appropriate for the three different scenarios that have been described previously, the next step was to consider the main elements and details that would inhabit them. As has been described by Chapter Three, which outlined the theoretical approach of this research, the intent was for the illustrations to be socially constructed. This is to say that rather than 'designing' the graphic social futures, the scenarios are curated based on the information gathered through Data gathering sessions One, Two and Three. This was done as a means of reducing the influence of the personal preferences and inherent bias of the designer on these research outputs. Whilst it is not possible to completely remove all bias from the decision making and design process, being critically aware of this issue did aid in mitigating the issue. This was the reason for introducing the critical lenses, providing a way to understand how the futures that the public described could come to pass, when combined with the backcasting method. As a result of this methodology, each aspect of the illustrations and each detail that has been included (or omitted) can be traced back to the information gathered across the three data gathering sessions.

When discussing their approach to design fiction, the *Near Future Laboratory* state that "the future is unevenly distributed and somebody's future is somebody else's present it is common to stumble on some concepts that are already real products/services or Kickstarter projects" (Girardin, 2015). This resonated a great deal with the findings of the data gathering sessions, whereby a surprising number of responses for the expected future uses of 3D printing are already possible today. There were of course some rather fantastical suggestions, such as hoverboards, spaceships and robot horses etc, but the majority of the proposed use cases are extremely possible and, in some instances, already common place for existing users.

It was therefore necessary to strike a balance between accurately representing the expectations and anticipations for the future of consumer 3D printing, but also presenting a grounded and recognisable alternative future reality. To achieve this, this research uses a combination of backcasting, as explained in Chapter Three, and visual hooks, which will now be discussed. Taking the example of a 3D printed supercar or yacht (which was a popular response from Data gathering session One), and simply presenting it within a near future scenario would most likely break any suspension of disbelief for the viewer. Following the process of backcasting however, the 3D printed supercar is used as a suggestion for a far more distant future in which 3D printed supercars are a common sight. This possible future can then be used as a starting point to work backwards from, considering what stages of development could potentially be taken along the way that could ultimately lead to this becoming a possible future. In this example it could simply be 3D printed cars or motorcycles, which are a reality today, and show that potentially in the future, more sophisticated and advanced 3D printed vehicles could one day become a possibility. Therefore, the inclusion of a 3D printed car or motorcycle within one of these scenarios is acting as, what this research refers to as, a visual hooks (as described in Chapter Three). These visual hooks are small visual clues littered throughout the illustrated scenarios that provide entry points into the imagined world (Coulton *et al.*, 2017). For those however who view the graphic social futures and are not interested, for example in 3D printed vehicles, the aim is for these visual hooks to simply be considered as another contributing background element that helps to describe a possible future. In this way, they act as visual prompts to help the viewer to construct their own world and develop their own narrative around how they could see themselves living in this alternative future. It is not intended that every visual hook resonates with every participant, they are merely intended as a scaffolding to support a discussion and encourage the viewer when considering this future.

The way in which the graphic social futures have been created is a critical part of this research. Every major detail that has been included, and all those that have been intentionally excluded, can be interpreted by the viewer, therefore it is important to carefully consider each aspect of the composition. Whilst it will not be possible for participants to fully understand the reasoning or intentions behind the inclusion of these details, it is important for the rigour of this methodology that this be the case. Therefore, each of the complete compositions will be presented, accompanied by a detailed description of each major visual hook and the rationale behind its inclusion. Where appropriate this will refer to the findings from data gathering sessions one, two and three, and there will be an explanation of the real-world applications and developments of the 3D printed objects and artefacts that are being presented.

7.7 A Near Future Streetscape

This scenario [Fig. 7.4] responds to the popular expectation of being able to engage with 3D Printing technology anywhere and everywhere. The aim with this scenario was to show a population that represents a variety of demographics, interacting and living alongside the potential impacts of 3D printing technology. A busy high street was considered to provide an appropriate opportunity to showcase a number of the ideas that emerged during the data gathering sessions. The main elements of this scenario will now be discussed.

Figure 7.4 The Near Future Streetscape – This illustration depicts a speculative vision for a high street of the future where 3D printing has become commonplace. The street composition is comprised of elements taken from different areas within the towns of Blackburn with Darwen, in the North West of England.

7.7.1 The Street

This scenario was in response to those participants who expected to use 3D printing to produce Anything and Everything, using it Anywhere and Everywhere, in Specialist Shops Supermarkets etc. Inspired by the future mundane approach to design fiction, the starting point for this scenario was to produce a composite image comprised of different elements from the towns of Blackburn with Darwen, in the North West of England [Fig. 7.5]. Being that each of the data gathering sessions have taken place in the North West of England (though that is not to say that all the participants are from within this area), it was appropriate and important that the graphic social future should reflect the locale. The streetscape depicts what could be considered to be, a typical small to medium, town high street, with an eclectic mixture of architectural styles being represented, resplendant with their late 20th century 'improvements'. This approach to creating the backdrop for the scenario was considered a key part of retaining the audiences familiarity with the scene and providing a comfortable backdrop for the potentially more controversial elements that would be inserted within the scenario.

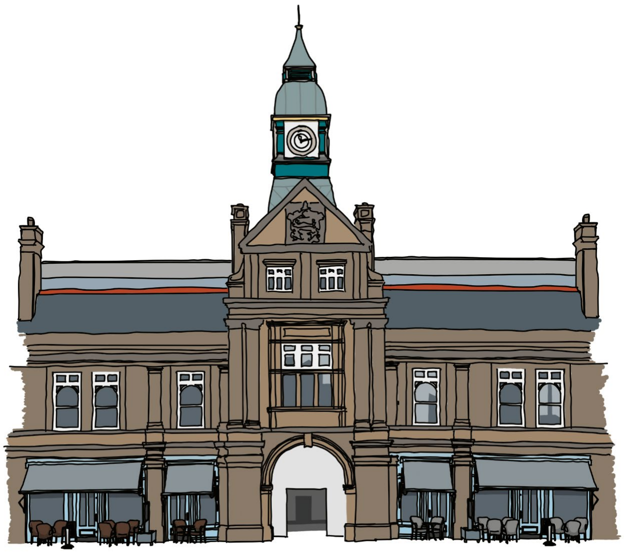


Figure 7.5 An illustration of Darwen Town Hall – This is positioned at the far end of the Near Future Streetscape scenario, alongside shop fronts found on a Blackburn Highstreet. These examples of the North West's architectural vernacular were chosen to make the audience feel comfortable with the speculative scenario being presented.

7.7.2 The People

This research is first and foremost concerned with understanding the social futures for 3D printing, it was therefore extremely important that a wide demographic of people would be represented within the illustrations. Whilst it is of course not possible to represent every demographic, those who were included are those which are most representative of the local population (based on data from Blackburn with Darwen Borough Council and photographic research), knowing that this location would also be the expected audience for the visual speculations.

7.7.3 The Shops

There are four shop fronts in the foreground of the image, each depicting one of the most popular expectations for how 3D printing technology would be accessed and exploited in the future. Going from left to right, the first store is the Bat Cave, a comic, and collectibles shop. The use of 3D printing for producing replica props, figurines and bespoke cosplay costumes was a popular topic of conversation in all three data gathering sessions. There is already a thriving online community of cosplayers and makers who produce customisable 3D printable designs for all manner of popular culture characters, such as full-size Iron Man armour as shown in the shop window. This was included following the conversations in data gathering session three concerning the makerspaces promoting the combination of art and technology and the uses that they see 3D printing being used for currently.

The adjacent shop offers a similar service but with a focus on high end fashion. Another popular expectation for 3D printing is the potential to produce bespoke clothing and footwear, which was suggested by 14 participants in Data gathering session One. This could involve the use of a large-scale 3D scanner which would allow for the 3D printing of bespoke clothing tailored exactly to our bodies. The shopfront shown is for *threeASFOUR* which is a trio of artists who combine technology with traditional craft to create their clothing. They have already produced and exhibited several collections of 3D printed clothing around the world. Whilst they are far from being a high street brand, this shows the possibility for how 3D printing could be used within fashion.

The next shop front, *Food Ink*, represents the possible use of 3D printing in the hospitality industry. There was a high level of expectation for 3D printed food in data gathering sessions one and two, with 28 participants expressing this expectation, it was also discussed in the third, but in a less positive light. *Food Ink* call themselves the world first 3D-prinitng restaurant. They currently operate as a pop-up restaurant where all the food, utensils and furniture are completely produced using 3D printing.

The final detailed shop front is *Fix Hub*, this represents the ability to easily repair and replace parts using 3D printing. Across all three of the data gathering sessions there was a great deal of positive discourse concerning the eco-effective potentials afforded by this technology, with 89 participants discussing this potential future use. *Fix Hub* depicted in this scene is a small network of community *makerspaces* that specialise in helping people repair or recycle their electrical equipment.

Each of these represent a way that 3D printing technology could become a ubiquitous tool for the high street in the future. That is not to say that every shop could benefit from this technology, nor that shops devoted purely to 3D printed artefacts and products would fill the high streets, simply that there already exist examples of 3D printing technology entering mainstream stores.

7.7.4 The Vehicles

The ability to 3D print vehicles was another popular topic of discussion, especially during Data gathering session One (Chapter Four) where 152 people responded that they would expect to 3D print a vehicle in the future, with a further 11 instead suggesting they expected to 3D print a motorhome. The motorcycle shown is the *NERA* e-motorcycle, which *bigrep* (manufacturers of large format 3D printers) calls the world's first full 3D printed e-bike. Aside from the electronics, the *NERA* comprises just 15 parts (including the wheels and tires,) which are all 3D printed. This would allow for an extremely customisable output simply by changing the filaments being used. The car being shown was designed and manufactured by *Local Motors*, a low volume vehicle manufacturer who produce open-source designs. This vehicle is called *Strati*, and whilst there have been other 3D printed cars, this was claimed to be the first to heavily utilise 3D printing technology. Whereas *NERA* is fully 3D printed except for the electronic components, *Strati* does have standard metal components for anything that is mechanically involved, such as the steering and suspension [Fig. 7.6].

These represent just two of the many 3D printed vehicles that are already available. These range in sophistication and complexity, but all show the potential for how this technology could be employed in the automotive industry. So far these are low volume vehicles, so the suggestion is not that they would replace the existing industry, it could simply be that those who are interested in modifying, restoring, or working with vehicles, would have another tool at their disposal

Figure 7.6 The NERA e-motorcycle and Local Motors – These are just two examples of 3D printed vehicles that are already being developed. Vehicles were amongst the most popular answer when Data gathering session One posed the question of what people expected to produce with 3D printing in the future.

7.7.5 The Robot

The anticipation of one day having the ability to 3D print a robot was shared by 12 participants in Data gathering session One. This is the first of two robots that appear within the illustrations, this one is depicted alongside a family, the intention being that it is a companion toy for the child. The robot shown is an enlarged version of the *PLEN* [Fig. 7.7], a small humanoid toy robot designed to teach introduce and robotics. There are several iterations of *PLEN,* each include some proprietary parts, but every design is open source, so most parts can be sourced or manufactured personally.

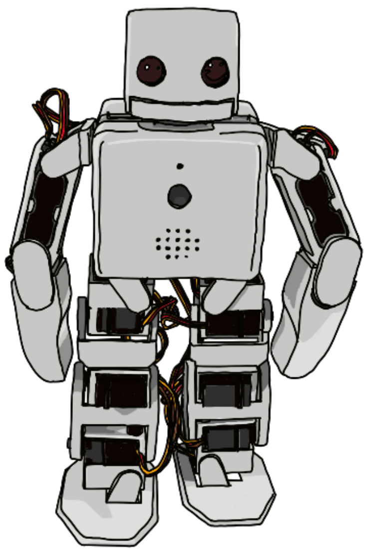


Figure 7.7 A supersized PLEN robot – This is shown as a companion for the child running down the street. This was included to show the possibility of a future where people are able to produce their own robotic companions and toys, which was a common expectation from Data gathering session One.

7.7.6 The Skater

The skater is a little less obvious in its inclusion, but his left arm is depicting an open-source bionic device. Across all three of the data gathering sessions, participants discussed the potential for 3D printing to be used in healthcare, 35 participants suggested they would expect to produce replacement body parts or prosthetics, with a further 30 suggesting that they would print in biomatter and organic materials. More specifically, during Data gathering session Three, I7 explained how they had been "working with the prosthetics and orthotics department, and they have been looking at how we can print things that have flexibility in certain areas but also strength and stiffness in others…" it "is very exciting as well, its filling a gap that needed to be filled." The prosthetic arm depicted in this scene is a product by *OPENBIONICS* [Fig. 7.8], who as the name may suggest, are an open-source initiative who work to develop affordable, adaptive robotic and bionic devices that can be easily reproduced using readily accessible materials and components.

Figure 7.7 Skater with a bionic arm – The skater was included to represent the use of 3D printing to produce bespoke prosthetics. The arm shown here is produced by Open Bionics, who produce bionic arms for children and adults in a range of unique and customisable styles.

7.7.7 The Construction

The final element in the streetscape for discussion is the construction scale 3D printer shown in the distance [Fig. 7.9], which was included in response to the 216 suggestions of 3D printing buildings. The printer is a scaled-up delta printer which prints concrete, this process of printing in concrete is also sometimes referred to as contour crafting. The model shown is by *WASP* who specialise in designing and manufacturing delta design printers. Concrete would be stored and mixed on site, in much the same way it is done on construction sites today, in the large silo's which would then feed the prepared material into the print head for depositing. The use of 3D printing for construction was consistently the most popular choice throughout data gathering session one and is therefore clearly something that the participants fully expect to see in the future.

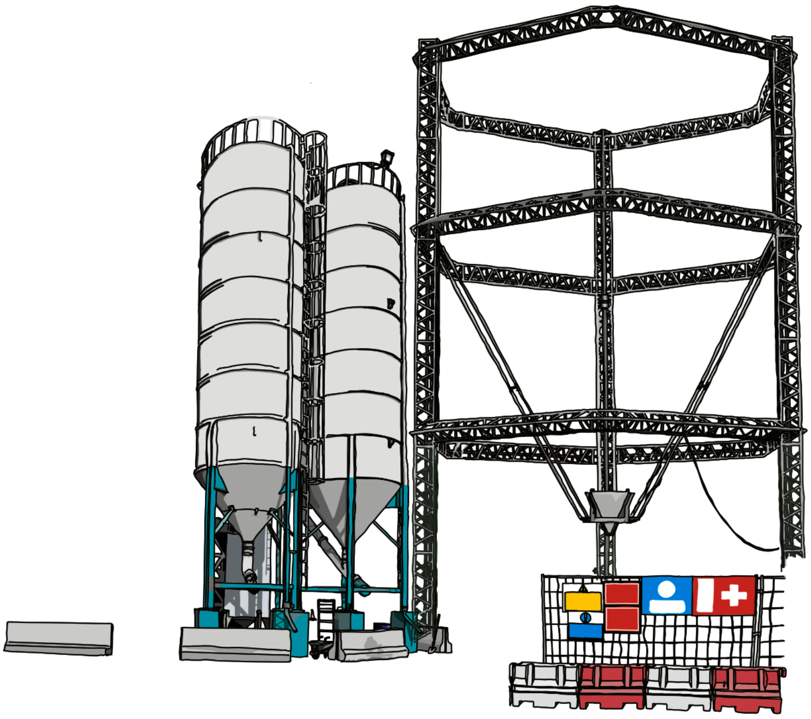


Figure 7.8 Construction scale 3D Printing – This large-scale 3D printer was included in response to the large number of participants who expected to use 3D printing to produce their own large-scale dwelling or improve upon their existing home. The printer depicted here is a WASP printer which is accompanied by a standard pair of concrete storage hoppers which can be found on construction site across the country.

7.8 Near Future Makerspace

The second scenario responds to the expectation of being able to engage with 3D printing technology in a social space that is accessible to the community, which accounted for 73 of the participant responses. Data gathering session Two (Chapter Five) revealed that a social or community makerspace is the second most popular location that people expect to access 3D printing technology in the future. Data gathering session Three (Chapter Six) then further revealed the aspirational ideas and positivity that people working in these spaces have towards the possibilities afforded by such spaces. One interesting finding was that even those participants who already have a 3D printer at home, thought that makerspaces were likely to be where people engage with 3D printing in the future. Those participants from a makerspace who did not already have a 3D printing device at home pointed out that as they had regular access to such devices and the necessary supporting devices, they had no need to have one in their home. Whilst the majority of participants across all three data gathering sessions expected to use 3D printing within the home, those participants who have the option of both using it at home or in a makerspace, most often find themselves using it in the latter.

7.8.1 The Space

Whilst the technology depicted within the streetscape can be found in the real world, it is far from common place, and is far from what would be expected on the high street in a small northern town. The makerspace however is a very different story, as there are thousands of maker spaces all across the globe, with each having access to a wide variety of digital and traditional fabrication technology, a selection of which is depicted within this scene. In a similar process to selecting the backdrop for the streetscape scenario, the inspiration for this scenario came from *The Making Rooms*, which is located in the centre of Blackburn [Fig. 7.11]. Each makerspace is different, mainly due to its location, its scale, it's users and the range of equipment that it offers. However, *The Making Rooms* is currently the best equipped publicly accessible makerspace in the UK. Whilst *The Making Rooms* is not necessarily the best laid out makerspace and certainly does not have the best designed interior, it was important for the methodology of this research that this depiction of the space should embrace these flaws and imperfections, to ensure that a more plausible and familiar near future is presented. Despite all of the technology which is made available for members of the public to engage with, at sites across the country, the vast majority of people this research engaged with, thought of this as something that would happen in the future, and were unaware that this was something happening in the present day. This scene does however include a number of elements that are not usually found within the same space, which will each be discussed over the course of this chapter.

Figure 7.9 The Near Future Makerspace scenario – This is based on The Making Rooms in Blackburn town centre, with the addition of several pieces of equipment and spaces devoted to other organisations that work with and alongside makerspaces, such as FixHub and FABCity.

7.8.2 The Signage

Across each of the walls there is large scale branding, each representing an organisation or an initiative that encourages community science and promotes sustainability. These have been included to represent a makerspaces ability to do much more than just provide access to equipment. On the far left is the FabLab logo, this is the global organisation that a makerspace can become a part of, this requires the space to offer open access days for the public to use the equipment free of charge. Not all makerspaces do this, but by agreeing to provide open access they are able to join the global network and community. Moving left to right, the logo on the far wall at the rear is for *Precious Plastics* [Fig. 7.12], which represents an idea discussed in all three data gathering sessions, with 42 responses indicating an expectation to 3D print using recycled plastics. *Precious Plastics* is an open-hardware plastic recycling project that aims to reduce global plastic waste. It achieves this by encouraging people to collect recyclable plastics and providing plans for the creation of plastic recycling machines. These machines allow for the creation of recycled plastic stock for milling, granules for injection moulding and filament for 3D printing. They also provide advise on how to create a recycling business, as such they are a good fit for a *makerspace* and provide a good example of the sustainable benefits of such an approach to making.

The next logo is *FixHub*, which is the same as that depicted in the streetscape illustration, this represents the 89 responses which strongly indicated an expectation for 3D printing to be used to further the life cycle of products. The production of replacement parts and repairing 'stuff' is already a popular use for these spaces, but not everybody has an interest in learning these skills themselves. A very common suggestion during data gathering session one and two was somewhere that could repair your items for you, something which is deemed to be very difficult to find at present. The next logo along is for *Fab City*, a global initiative which aspires to create locally productive, globally connected self-sufficient cities. The aim is to leverage the global community of the Fab Lab Network to work towards more sustainable and liveable cities. This speaks directly to the findings of all three data gathering sessions, whereby the sustainable potentials offered by 3D printing were very much anticipated and expected. The final logo is that of this makerspace*, The Making Rooms*. The FabLab is just one aspect of this community interest company, which like many *makerspaces i*s site specific and tailored to the needs of its users.

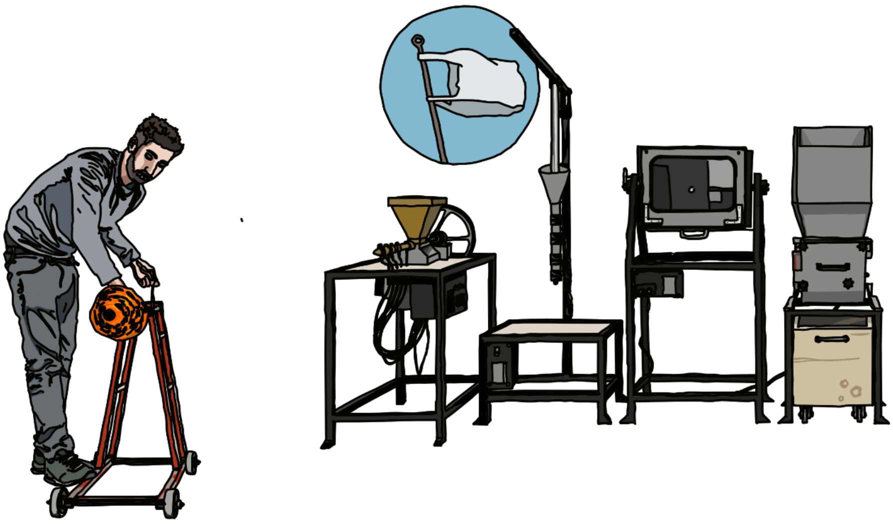


Figure 7.10 Precious Plastics machinery – This represents one of the projects that are associated with the Maker Movement. This collective promotes the recycling and reuse of plastics by providing a range of open-source plastic fabrication equipment. Precious Plastics along with FAB City and FixHub are included to show how the maker movement has given rise and contributed to the creation of other groups and organisations with similar aims and objectives.

7.8.3 The People

Much like the approach for populating the streetscape, there was careful consideration of what demographics would be represented. The background is filled with an illustration of the regular users at *The Making Rooms* [Fig. 7.12], which is a good representation of the local demographic. All of the other people included within the illustration were sourced from images of makerspaces around the world and so represent existing real-world users of these spaces.

Figure 7.11 Making Rooms staff and volunteers – The staff and regular users of The Making Rooms makerspace were included in the background of the scenario as this is a true representation of this space's user demographic.

7.8.4 The Making

There are two devices in the foreground being used, one of which is a 3D printer, the other a desktop milling machine. Whilst the focus of this research is of course 3D printing, judging by the findings of Data gathering sessions One and Two and the discussions around how people currently use the technology in Data gathering session Three, it suggests that there will need to be a variety of tools and equipment available to the public, considering that many of the project's people expected to use 3D printing for cannot be completed with 3D printing alone. Desktop milling is one such additional device [Fig .7.14], it enables the production of PCB prototyping and 3D milling of components. Within the composition there are also several other 3D printers, laser cutters, the precious plastics machines and an electronics workbench. Whilst it may be possible to create a great deal of what the participants expected using 3D printing, there will almost certainly be the need for additional specialist tools.

The pair of makers on the floor are working on an early prototype of a drone [Fig. 7.15], this was included in response to the many excited conversations during Data gathering session One around the prospect of people being able to design and make their own electronic toys, gadgets and models. The depiction of a drone was chosen as it is a recognisable example of one such project that would be more likely to succeed if it made use of the range of equipment available in such spaces, rather than solely relying on 3D printing.

Figure 7.12 A desktop CNC milling machine – Much of what people expected to produce using 3D printing in the future would require a combination of fabrication equipment to be used alongside 3D printing. It was therefore important to include a range of different fabrication equipment that can often be found in makerspaces as a means of normalising this idea.

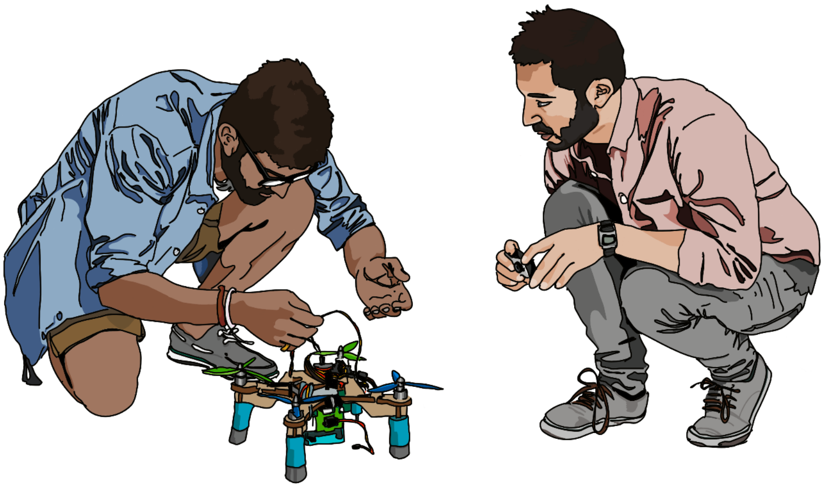


Figure 7.13 A DIY 3D printed drone project – The ability to 3D print the parts for a DIY drone was a popular response from Data gathering session One. This provided an opportunity to illustrate a collaborative project that makes use of a variety of equipment commonly found within a makerspace and is a relatively recognisable artefact.

7.9 Near Future Domestic Workshop

This scenario represents the domestic environment [Fig. 7.16], which was the most popular location that participants expected to use 3D printing technology in the future across both Data gathering session One and Two. Data gathering session Two further revealed that the most anticipated location within a domestic setting that people would likely set up a 3D printer would be a garage or shed, closely followed by a home office or study. It was therefore decided to depict a garden workshop that represented a converted garage or garden shed. The main aim with this scenario was once again to depict 3D printing technology as an established technology that has found its way into the home and is being used alongside all the other tools and equipment that people are already familiar with. In an effort to showcase the potnetial that this new technology affords, it was necessary that the project being worked on within the scene be intentionally eye catching and something that would likely not be possible in a domestic environment without access to 3D printing technology.

Figure 7.14 The Near Future Domestic Workshop – This scene depicts a converted garage workshop, complete with a mixture of traditional tools and equipment, alongside some digital fabrication devices. Like many workshops, there are signs of multiple projects underway and shelves of works in progress.

7.9.1 The Space

This was perhaps the most difficult composition to begin, as the domestic environment is an extremely varied thing, so the decision was made to depict a garage that has been converted into a workshop. Whilst this is a very generous sized space that not everybody would have access to, a large space was necessary to include all the elements that the research had suggested people expected, and to make it a plausible scenario. The backdrop depicts a well-equipped home workshop, with a collection of old wood working machines, such as table saw, belt sanders and pillar drill/milling machine, alongside a plethora of toolboxes and workhorses which are buried amongst them. To the right of the scenario there is more of a focus on electronics, with a collection of older tools and devices on the shelves, making room for a 3D printer and computer on the desk below. This is a good example of the future as an accretive space, where older technology is pushed out of the way by newer devices and equipment, but the old remains and is simply 'tidied' away.

7.9.2 The Robot

Taking centre stage in this composition is a robot being assembled on the table saw extension. Whilst the first robot to be included in these illustrations (*PLEN* shown in The Near Future Streetscape) represents a child's toy, albeit a rather large and relatively advanced one, the robot depicted here is far from being a toy. Amongst the participants of Data gathering session One there was a popular expectation or ambition to produce complex machines and devices, 7 participants suggested a Jet or Jetpack, 4 suggested Helicopters, 8 would produce a Spaceship or Rocket and 12 wanted to build a robot. The robot show here is the *InMoov* [Fig. 7.17], project which was started by French sculptor Gael Langevin, who wanted to create something more than another static human model. With no prior experience in robotics, but with plenty of help from the open-source community, he has led the creation of a moving, talking robot. The whole thing is designed to be assembled from 3D printed parts, all of which can be produced on a device with a build area of only $12cm^3$. The project is intended as a robotics development platform for hobbyists and makers but has also been replicated by Universities and Laboratories across the world (Langevin, 2020).

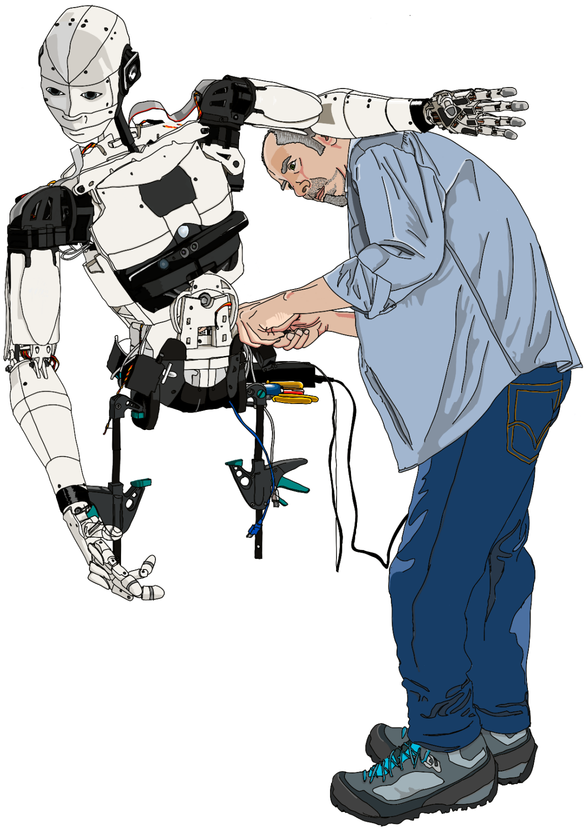


Figure 7.15 A DIY 3D printed life size robot – The InMoov project is an advanced open-source robot, designed to be fully 3D printable (with the exception of electronic components) and easily assembled by hobbyists and makers.

7.9.3 The Parts

The most common expected and anticipated use for 3D printing is something that appeared across all three data gathering sessions, the repair and replacement of parts. This use case for 3D printing received 89 responses in Data gathering session One and 51 in Data gathering session Two. Many participants were also strangely specific in their responses, people want to be able to fix their vacuum cleaners, so it seemed fitting to include these elements [Fig. 7.18]. This is a good example of a relatively easy fix for 3D printing, as often the issue of a broken vacuum cleaner is the need for a replacement hose coupling or to replace a cracked section of an attachment etc. This is something that 3D printing is very well suited for, with little effort required to model and produce a replacement part, a rather expensive electrical item can continue its useful life and avoid landfill. The bucket of parts is a nod to the fact that invariably once friends and family know that you are capable of repairing such a thing, there will no doubt be others that need your assistance. However, with a far more interesting project sitting on the workbench, these more utilitarian projects often languish at the bottom of the to-do-list.

Figure 7.16 3D printable replacement parts – The ability to print replacement parts for home appliances and other electrical devices is a common expected use case for 3D printing. The potential for inexpensive repairs, increasing the lifespan of products and preventing their consignment to the rubbish pile is certainly one of the messages concerning 3D printing that has been communicated well.

7.9.4 The Stuff

This composition more so than the others shows that the future mundane is an accretive space [Fig. 7.19]. The 3D printers sit alongside old oscilloscopes, function generators and retired computers. The workshop provides a perfect environment to indicate how new technology will be added to a scenario, but rarely will it replace something. A domestic workshop is typically something that is developed over time and includes a wide variety of machines and tools specific to the user and their interests. Old tools can hold a great deal of sentimental value and often the adage of ‘they don’t make them like they used to’ is true. Several users from *The Making Rooms* have home workshops which are full of old machines that were rescued from business who were upgrading or closing shop, and they are performing just as well today as they always have. The intention here is to once again show that to exploit 3D printing to its truest potential, it is best used alongside other tools and equipment.

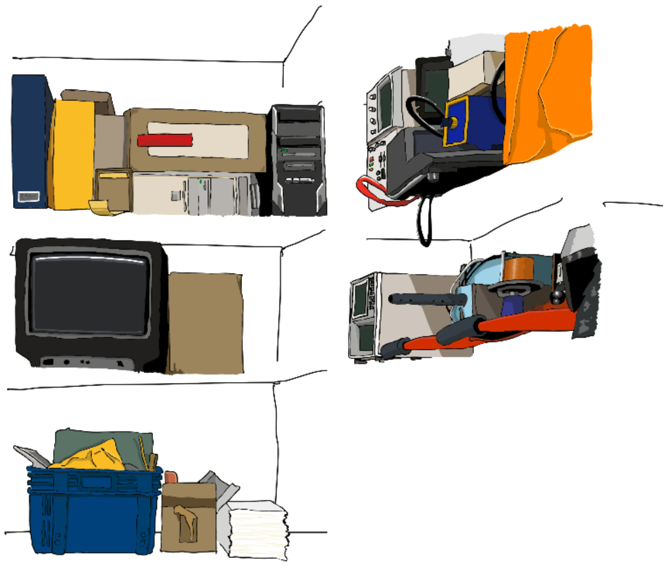


Figure 7.17 Unfinished projects and spare parts – This is perhaps the most fitting example of the future mundane influence, the idea that the future is an accretive space. Craftspeople today use well-made tools and equipment from the mid-20th Century, so it seems appropriate to suggest that a near future domestic workshop would also have signs of present-day equipment and devices.

7.10 Conclusion

The visual hooks discussed here represent the main ideas as revealed by the data gathering sessions. The intention is that these will act as hooks to draw the audience into the scenarios and aid in the construction of their own alternative future imaginary. For those who recognise a visual hook it will provide an entry point into this fictional world, for those who don’t recognise it as meaningful, it should simply be a part of the backdrop. The significance of these visual hooks is therefore extremely dependant on the individual viewing them, they act as doorways into these speculative worlds, which the viewer can choose to engage with or ignore.

Each of these graphic social futures has been created at scale to be presented on an A1 exhibition board. This was done to ensure that all of the visual hooks and minor details of the illustrations would be visible. Whilst it is not possible to show these at the desired scale in this thesis, they are shown below at the largest scale possible (Near Future Streetscape [Fig 7.17], Near Future Makerspace [Fig 7.18], Near Future Domestic Workshop [Fig 7.19]).

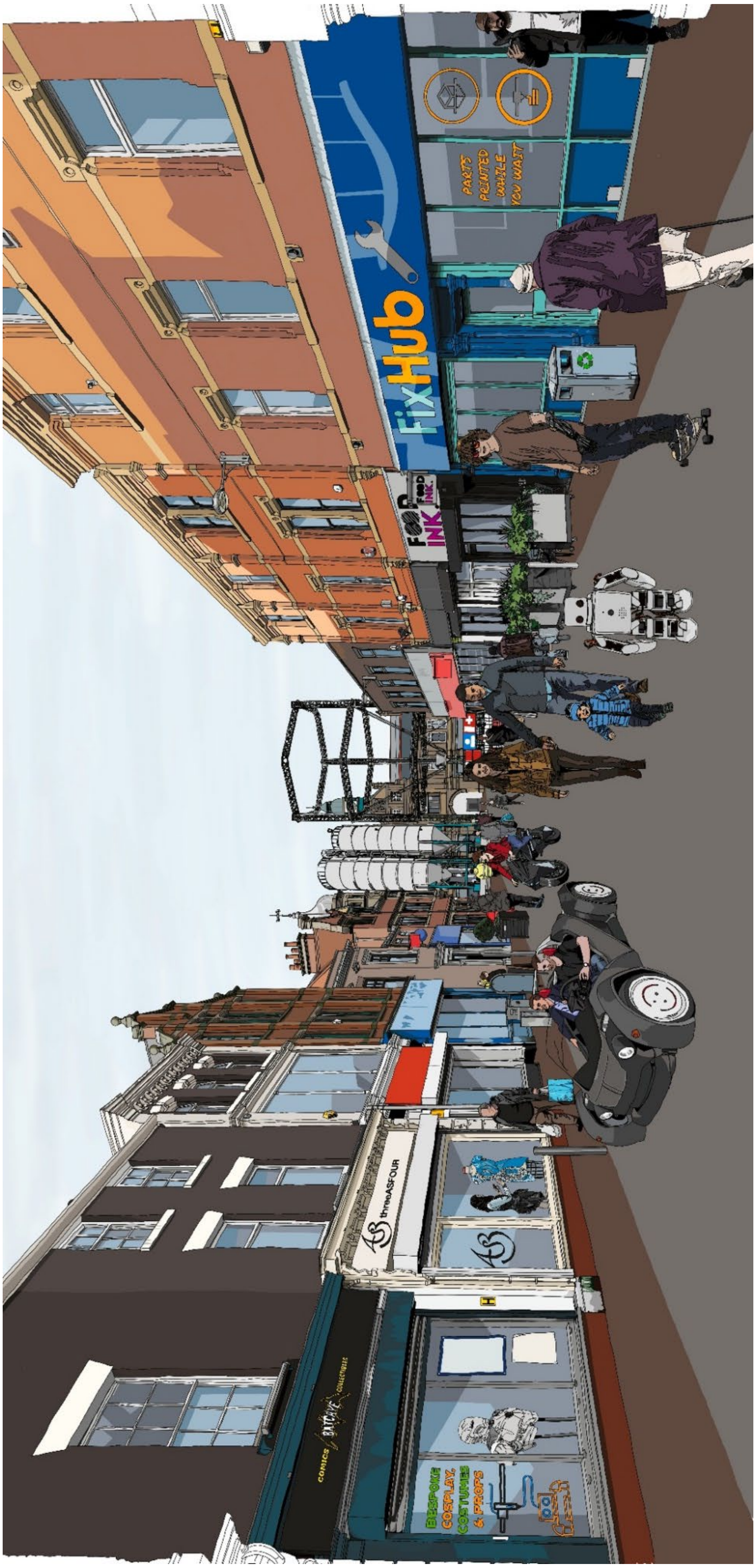


Figure 7.18 The Near Future Streetscape, shown at approximately 12% of its intended scale.

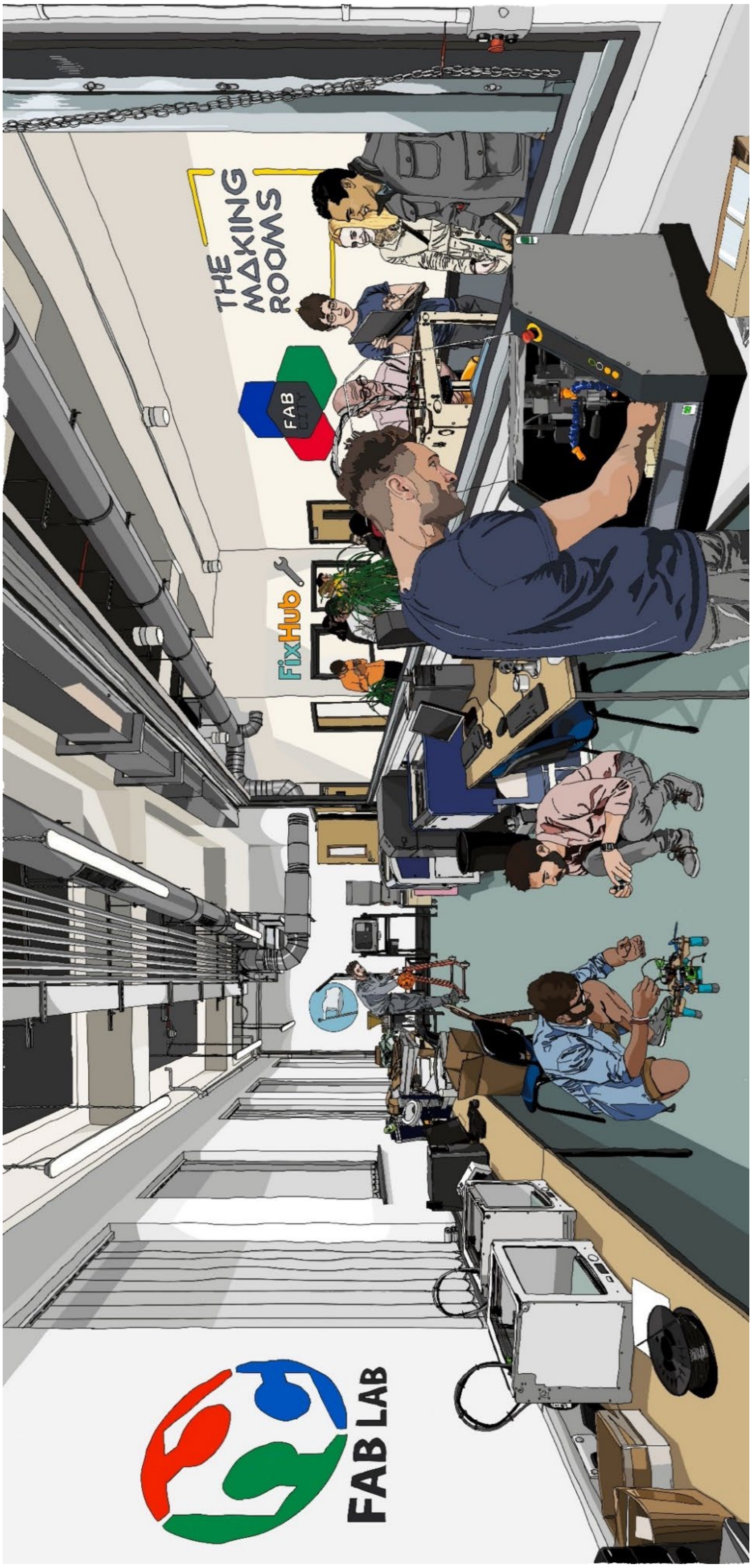


Figure 7.19 The Near Future Makerspace, shown at approximately 12% of its intended scale.

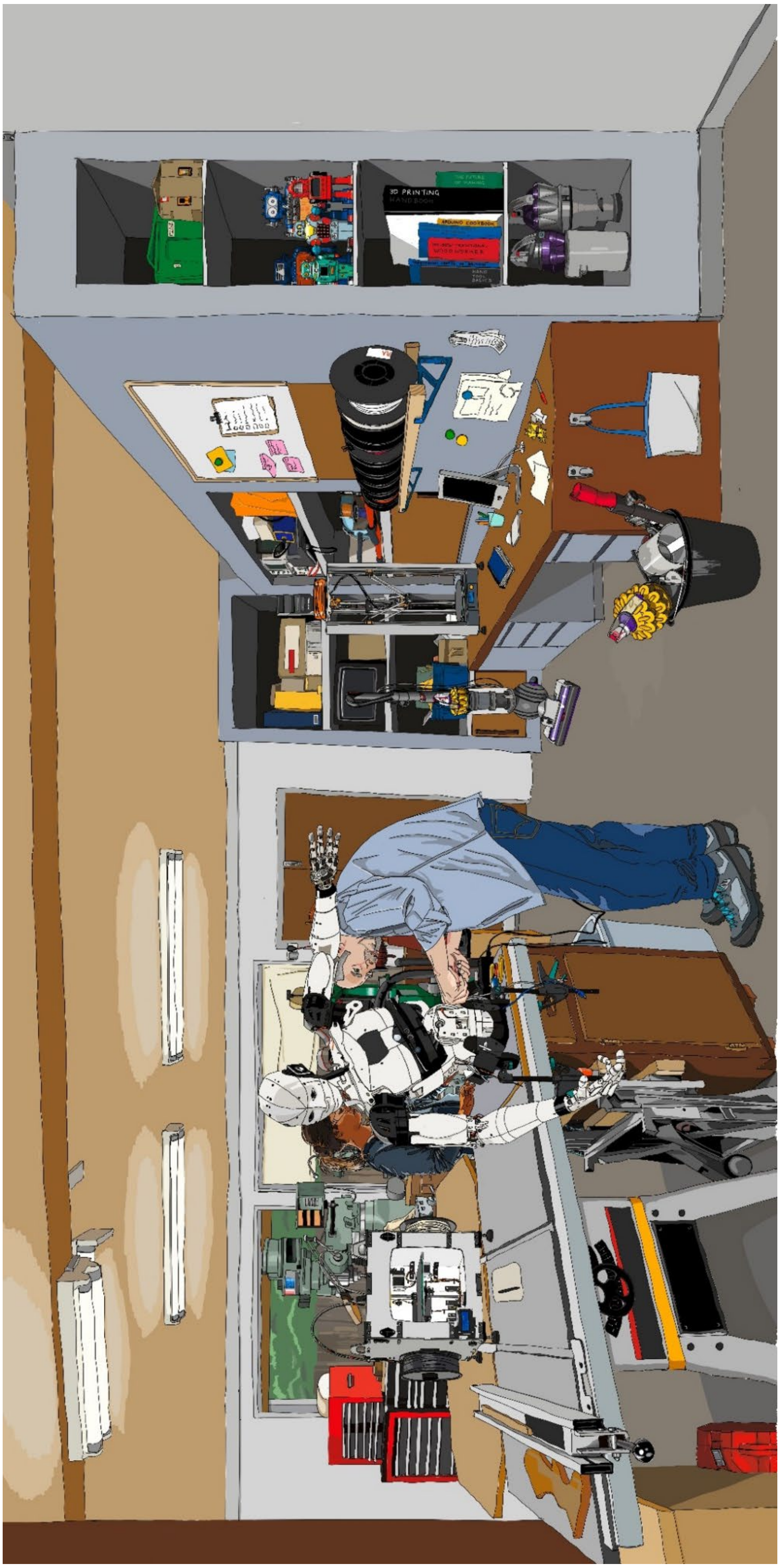


Figure 7.20 Near Future Domestic Workshop, shown at approximately 12% of its intended scale.

8.0 Data gathering session Four: Research Survey

8.1 Outline

This chapter describes the fourth and final Data gathering session, which used the graphic social futures as a platform to discuss the future of 3D Printing with the public. This is presented in two parts, the first part explains the process of designing this data gathering session, with the second part discussing the results that were collected. Part one begins with an explanation of how the global Covid-19 pandemic affected this research, followed by the measures taken to mitigate these problems and ensure this research could continue. The design of the research survey is then explained, including how the accompanying questions were formulated. Part two begins with a discussion of how the survey performed, using the statistical data provided by the survey's online platform. This is followed by an explanation and analysis of the results that the survey collected, which is drawn to a close with the conclusion.

8.2 The 2020 Experience

Having completed the graphic social futures illustrations, the plan going into 2020 was to have each of the compositions printed onto an A1 presentation board which would then be exhibited at several *makerspaces*, facilitating a discussion around the ideas being presented. In a similar manner to Data gathering session One, the intention was for visitors to the exhibitions to be encouraged to 'post' their thoughts, comments, and any responses they had to the scenarios, around the board. In addition to encouraging visitors to contribute to the comments board, there would also be a series of recorded public discussions, to not only collect data on how people responded to the illustrated scenarios, but also to understand how participants engaged with the process. Unfortunately, as everyone is all too aware at this point, the year 2020 was not something that anybody could have prepared for, and with the national lockdown coming into effect, all research plans were halted.

At this stage there were two options, the first was to postpone Data gathering session Four until the outbreak was under control and the lockdown restrictions were relaxed. The second option was to consider an entirely new strategy for how to disseminate the graphic social futures to a virtual audience and how to collect their responses and reactions to them. In the early stages of the lockdown there was a certain level of optimism that this would be a brief inconvenience and that things would be back to 'normal' in only a short period of time, therefore the initial thought was to place a temporary halt on this stage of the research and wait it out. As time went on however, it became increasingly clearer that the Covid-19 virus was not something that the country, or indeed the world, had been prepared to handle, and there was no way of knowing how long the lockdown measures would be in effect across the United Kingdom. Therefore, the decision was taken to begin planning for a different approach, one that would be entirely virtual, meaning that it would be possible to proceed with Data gathering session Four, regardless of the pandemic's restrictions.

This presented a series of challenges, particularly as all of the data gathering sessions had been planned as in person events or activities, and the graphic social futures had been designed and produced as large-scale artworks with the intention of exhibiting them. Therefore, the question of how to remotely engage with a large group of participants and capture and record their responses was not something that had been considered until this point in time. The solution was provided by one of the supervisory team for this research who suggested that the online survey tool *Typeform* could provide an appropriate platform for this research, having successfully used it themselves. Typeform is an online form and survey building service that aims to create dynamic forms based on the user's needs. Following preliminary experimentation with the software it was decided that a research survey would be the most appropriate format for Data gathering session Four. The remainder of this chapter describes the process of designing and creating this data gathering session, followed by a discussion of the findings.

8.3 Asking the Right Questions

As has been discussed in Chapter Three, this approach to design fiction research was partly inspired by the work of Strange Telemetry. As such, when it came to devising a series of questions that would guide participants through the process of considering futures, their approach to the Ageing

Population project was used as a precedent. This led to the field of creative thinking methods, specifically Edward De Bono's (2017) *Six Thinking Hats* method. The six thinking hats is a critical thinking tool designed to aid in group discussions and individual thinking, there are six hats, each of which is a different colour. Each of the six different coloured hats is assigned a unique function, a lens if you will, through which each participant is asked to view the topic of discussion. Used in this way the 'thinking hats' encourage people to consider things from different perspectives.

There are numerous ways in which the six coloured hats have been described and assigned their function, the one that was discerned to be the most appropriate is described below [Fig 8.1]. Whilst this tool is primarily intended for use in a group situation, it can be used by individuals, by asking them to 'wear' each of the hats in turn (view the scenarios through that particular lens), rather than simply assigning each person only one.

An advantage of this method is its ability to encourage the participants performance by separating the ego, as it is no longer about the individual but the problem and solving the problem (Voss *et al.*, 2015b). However, due to restrictions imposed by the national lockdown, this research could not be a physical group activity, and therefore an alternative approach to using this method was considered necessary. Rather than having a lengthy and potentially complicated explanation concerning how the graphic social futures are to be viewed and critically considered, a question that aligns with each of the critical thinking hat's unique function will be produced. Used in this way the participants were still asked to look at the 'problem' through different lenses, without the need to first understand the six coloured hats approach. This was important as the hands off and remote nature of the online research survey meant that this needed to be completely stand alone and as straight forward and self-explanatory as possible, to avoid unnecessary confusion.

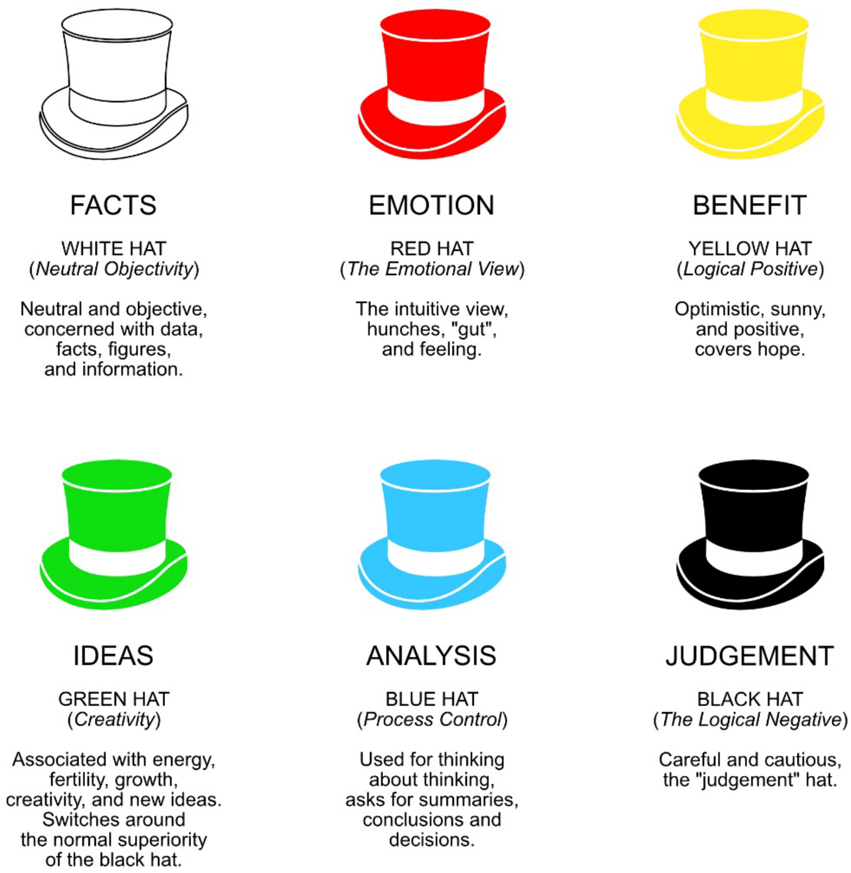


Figure 8.1 Diagram of 'The Six Thinking Hats', Edward De Bono, 2017 *(redrawn by author) – This approach to critical thinking was adapted for use in this research survey. The six different colours relate to six different lenses through which each participant is asked to consider the illustrated scenarios, by answering the appropriately aligned question.*

The *Six Thinking Hats* approach to critical thinking was used as a guide to develop the series of questions that would be asked of the participants. Each of the questions would be designed to relate to one of the different 'hats' and would be used to encourage the participants creative thinking. The intent was that once a participant had considered each of the questions, they would have been challenged to think about what they think, by reflecting on their thoughts and understanding.

To devise the six questions that would accompany each illustrated scenario, the first step was to consider the three illustrations, and what the participants needed to reflect on when viewing them.

The first iteration of questions used the diagram as a starting point, however, when asked in this manner the questions did not easily segue from one question to the next. This was considered problematic as the research survey needed to be as easy and engaging as possible, due to concerns over sufficient participant numbers, considering that a remote data gathering session was to be a very new and untested experience for this research. It was therefore decided that the best order for the questions was as follows:

Red: Imagine that you are in this near future scenario, what are your gut feelings about it? Do you feel…

Green: What do you like about being in this scenario? Are there things that resonate or are familiar?

Blue: What do you dislike about being in this scenario? Are there things that you disagree with or find unlikely?

Yellow: What do you think the advantages or benefits of being in this future would be for you? Or why do you think that this future could work?

Black: Can you think of any reason that this future would not be possible, or would not be desirable for you?

White: If you were in this scenario, what else would you like to see included? Is there something missing that you would have expected to see in a future where 3D Printing technology was commonplace?

These same six questions were asked for each of the three illustrations in turn. During research into the six thinking hats method and its applications in previous research, it was revealed that in some instances a seventh hat had been introduced. This seventh hat represented the owner, who is subjectively seeking objectivity. At this stage in the survey design there was some concern regarding the length of the survey, the worry being that people would be less willing to spend time answering questions for an online survey, than if they had been engaging with the research in person. It was therefore decided that a single question added at the very end of the survey could represent the seventh hat, this question was:

Purple: How easy/difficult did you find the process of considering these future scenarios? (with a sliding scale provided for responses)

Each of these questions was designed to uncover how the public were responding and reacting to the graphic social futures that they were presented with. This research has taken the view that an important aspect of social *futures* is concerned with giving a voice to everybody, this survey is intended to provide a platform, with the speculative illustrations providing a framework, to help give people a voice and guide them in considering alternative *futures*.

8.4 Designing the Survey

The next challenge in converting this research from a physical exhibition and discussion into a digital survey was deciding on the design and format. This was quite a departure from the original plan considering that the illustrated artwork was produced at an A0 scale with the intention of scaling it down to be printed and mounted at A1. Ideally, every participant would view and complete the survey on a widescreen, high resolution device, however, it was expected that some participants would likely attempt to complete the survey on a small handheld device. This next section describes the thoughts and considerations that went into translating this in person data gathering session into an online data gathering session.

The next matter for consideration was how to attract a number of participants comparable to the earlier data gathering sessions, without the advantage of a large-scale festival or an existing network of makers to engage with, as had previously been the case. Being that this data gathering session would be taking place entirely within the digital realm, it would need to be visually attractive to grab people’s attention, and intriguing enough for them to agree to take part in the survey.

The first step towards this was creating a visual meta tag for the survey, that could be shared across social media platforms and posted to mail lists. Once the meta tag was clicked on [Fig. 8.2], the hyperlink would take the participants to the first page of the survey. The survey ‘title screen’ made use of an illustration of a delta style 3D printer and was accompanied by a short tag line thanking people for taking part in this study, that was very much hoped would encourage people to hit the ‘Let’s get started’ button. Whilst this might seem like a trivial thing to spend time worrying about, statistics suggest that typically online surveys have only a 29% completion rate (Lindemann, 2019), so it was important that every aspect of the survey be as enticing and visually engaging as possible, to reduce participant drop-off where possible.

Figure 8.2 Graphic design elements from the research survey – The Open Graph Meta Tag for the research survey was produced so that clicking on this from any online platform would hyperlink to the title screen of the survey, hosted by Typeform.

This challenge was particularly difficult for the next section of the research survey, which was the participant information and consent. There were very few options to make this an engaging experience, but it was also something that could not be excluded. One of the main aims when designing this survey was for it to be as straightforward and quick to complete as possible, which was extremely difficult to achieve with the lengthy participant information and consent form, the best solution was to include the participant information in its entirety as one scrollable page, participants simply needed to scroll to the bottom and select continue. The participant consent unfortunately could not be handled in the same way, each of the statements required confirmation that the participant had read and understood it, therefore there was a series of five statements, each with a drop down yes or no option to provide consent, each of these was mandatory to continue onto the next 'page'. Once a participant had provided consent for their comments to be used in this research, they were presented with a scrollable page which provided the context for this research survey. Ideally this would not have been necessary, as this was yet another point at which it was feared the participants would elect to continue no further with the survey. However, this was deemed necessary as it would provide the participants with background context to better understand the research and therefore better understand what is being asked of them.

The survey actual began on what would be the ninth page, though to obfuscate the length of the survey, up until this point the participant information, consent, and background information had been labelled ***a*** through to ***f***. Before beginning with the research questions, the illustrations were first introduced. As has already been discussed, this survey was intended to be completed on a widescreen desktop monitor or laptop, so the major consideration at this point was presenting the illustration at the largest scale possible. This led to a further challenge, due to the editing restrictions of the Typeform software, it was impossible to have the illustrations as a large-scale background image, overlaid with legible text for the questions. The solution was to have an introductory title page for each of the graphic social future scenarios which featured a small-scale version of the illustration and an instruction to study the following image, which was immediately followed by a whole screen illustration. Although less than idea, this was considered to be the best solution out of the many iterations that were attempted.

Following on from the full screen illustration, participants were then shown the small-scale version of the illustration accompanied by each of the questions, as previously described and shown in figure 8.4. Each of the questions was also accompanied by a hint or tip, which provided a little more guidance on how the participants should approach the questions, e.g. 'Try to look past issues of town planning or building aesthetic and focus on the ideas being represented here'. These were included to help steer the participants through the process, the need for which arose following several tests of the survey with colleagues, when it became apparent that their focus was often drawn to issues outside of this research interest. Whilst it is not possible to prevent this from occurring, these tips were introduced in efforts to mitigate this where possible.

a.

1→ First things first...Participant Information.

On behalf of the Institute for Social Futures (ISF) and the Lancaster Institute of Contemporary Art (LICA) I would like to invite you to take part in this research. Before you decide it is important you understand the aims and background of this research, what it will involve, and your rights as a participant.

My name is Matthew Pilling. I am a PhD student at Lancaster University and the principal researcher for this research. I would like to invite you to take part in a research study that aims to understand how effective a tool, visualisations can be in futures research.

Please take time to read the following information carefully before you decide whether or not you wish to take part.

What is the study about?
This study is about understanding how effective visualisations can be for questioning the future of technology and its role in society. In this instance the technology in question is 3D Printing.

Why have I been invited?
This research is concerned with social futures, that is to say, futures that are accessible to everybody, as such I need a board range of input to interrogate my illustrations. I would be very grateful if you would agree to take part in this study.

What will I be asked to do if I take part?
If you decided to take part, this would involve the following:

You will be presented with three illustrations which have been informed by previous workshops, interviews and public discussions. You will be asked to browse each image, and then answer six questions in response to these images. Each image depicts a near future scenario with many subtle changes suggesting how 3D technology could diffuse into our everyday lives. This research is not concerned with discovering if the scenarios depicted are possible, probable or preferable, but instead seeks to see if these illustrations align with peoples expectations or anticipations for 3D Printing technology.

What are the possible benefits from taking part?
By taking part in this study you will have the opportunity to share your thoughts and ideas about the future of 3D printing and contribute to our understanding of futures research.

Do I have to take part?
No. It's completely up to you to decide whether or not you take part. Your participation is voluntary. You have the right to withdraw from the study without providing any reason for your withdrawal at any time of participation or during data collection.

What if I change my mind?
If you change your mind, you are free to withdraw at any time during your participation in this workshop. If you want to withdraw, please let me know, and I will extract any ideas or information (data) you contributed to the study and destroy them. However, I should point out that as all data collected will be entirely anonymous and your representation in the end research will also be completely anonymised it will become difficult and near impossible to take out data from one specific participant when this has pooled together with other people's data. Therefore, you can only withdraw up to 2 weeks after taking part in the study as at that point all data will be collated and possibly used.

What are the possible disadvantages and risks of taking part?
You will have to give up some of your time to complete the survey, but otherwise there are no other disadvantages to taking part.

Will my data be identifiable?
I will use the information you have shared with me only in the following ways:
I will use it for research purposes only. This will include my PhD thesis and other publications, for example journal articles. I may also present the results of my study at academic conferences.

When writing up the findings from this study, I will reproduce some of the views and ideas you have shared with me, however all data will be anonymised, so although I will use your exact words, you cannot be identified in any publications.

How will we use the information you have shared with us and what will happen to the results of the research study?
I will use the information you provide for research purposes only. This will include the principal investigators PhD thesis, which may be submitted to associated publications for academic journals. I may also present the results of this study at academic conferences, and at the conference of the project funders.

How my data will be stored
Your data will be stored in encrypted files and encrypted servers due to the nature of the digital workshop and extraction of data (that is no-one other than the research team will be able to access them) and on password-protected computers. I will store hard copies of any data securely in locked cabinets in our office. I will keep data that may identify you separately from non-personal information (e.g. your views on a specific topic). That said, your identity will be anonymised, for example, 'Participant A'. In accordance with University guidelines, we will keep the data securely for a minimum of ten years.

What if I have a question or concern?
If you have any queries or if you are unhappy with anything that happens concerning your participation in the study, please contact myself:

Matthew Pilling
m.pilling@lancaster.ac.uk

If you have any concerns or complaints that you wish to discuss with a person who is not directly involved in the research, you can also contact:

Prof. Judith Mottram,
Professor of Visual Arts, Director of LICA
Lancaster Institute for Contemporary Arts
Lancaster University,
Bailrigg, Lancaster
LA1 4YW

Telephone: +44 (0)1524 594395
Email: judith.mottram@lancaster.ac.uk

Continue press Enter ↵

b.

a I confirm that I have read and understood the information provided for this study. *

Type or select an option

c.

b I understand that my participation is voluntary and that I am free to withdraw at any time during participation in this study, without giving any reason. *

Type or select an option

d.

c I understand that any information given by me may be used in future reports, academic articles, publications or presentations by the researcher/s, but my personal information will not be included, and I will not be identifiable. *

Type or select an option

e.

d I understand that data will be kept according to University guidelines for a minimum of 3 years after the end of the study. *

Type or select an option

f.

e I confirm that I am 18 years of age or older and agree to take part in this study. *

Type or select an option

g.

What's this all about then?
I am exploring and developing new methods for research into the social futures of 3D Printing technology. This survey is about understanding how successful illustrations are as a tool to discuss the future of technology.

What are Social Futures?
"The idea of social futures is to try to get away from the idea that futures are dependant on or determined by technologies or that they are simply derived from the ways in which the present is unfolding. It is not about predicting and telling that this is the way the future is going, it's about a realistic, well informed and imaginative look at different likely scenarios for how we may, or could, or should go, and of course they can be back cast to look at our current situation as well."
(John Urry 2015)

What is 3D Printing?
3D Printing (Additive Manufacturing) is a process for making physical objects from a three-dimensional digital model(virtual), typically by laying down many successive thin layers of a material(physical).

What do I need to do?
Over the past few years I have been discussing 3D Printing with people to find out what they are expecting and anticipating from this technology. The results of these conversations have been used to create three large scale illustrations that represent future scenes in which 3D Printing has entered into our everyday lives. These are not far future predictions, but instead are an attempt at depicting real world situations, wherein which this new technology has been placed.

Each of the three illustrations will be presented to you, accompanied by six questions. You will be asked to imagine that you are within these future scenarios and imagine what it might be like to live within this reality. This is about your personal response to the images presented, some of you might not think this would have much of an impact, others much more so, there is no right or wrong answer. Every detail and element included within these illustrations has been considered, so try to take in as many of these details as possible. If you are viewing this on a mobile device please ensure that you do so in the landscape orientation, otherwise the images appear very cropped. Answer with as much detail as you like.

If you would like to discuss any of this research with me further, please do contact me at **m.pilling@lancaster.ac.uk**.

Thanks again for taking part!

Continue press Enter ↵

Figure 8.3 Research ethics information as it appeared in the research survey – Research Ethics required that participant be provided with the complete participant information [a] and an accompanying consent form [b, c, d, f] that each participant had to complete before the survey could begin. Once they had confirmed they were happy to partake in this research, they were provided with a brief explanation of this research [g].

This format and layout of the illustrations and questions was repeated for each of the three graphic social future scenarios, with the wording of the tips for participants being the only small changes throughout. In total there were twenty-one questions, as in addition to the six that have already been discussed, participants were also asked if there was anything else they would like to say for each of the illustrations. The final survey question was the additional 'Purple Hat' question, concerned with discovering the ease or difficulty that participants experienced with the survey, shown in figure 8.5. Participants were then invited to provide their email address if they wished to take further part in this research, which will be the topic of discussion in Chapter Nine. The final page was a short thank you note and links to share the research survey onto social media platform of their choosing.

Figure 8.4 Graphical layout for the research survey – Each of the three graphic social futures were presented in the same manner as shown above. A full screen image was provided at the outset of each scenario's questions,

with the instruction to study the image before progressing to the questions. Each question was also accompanied by a smaller version of the illustration in question.

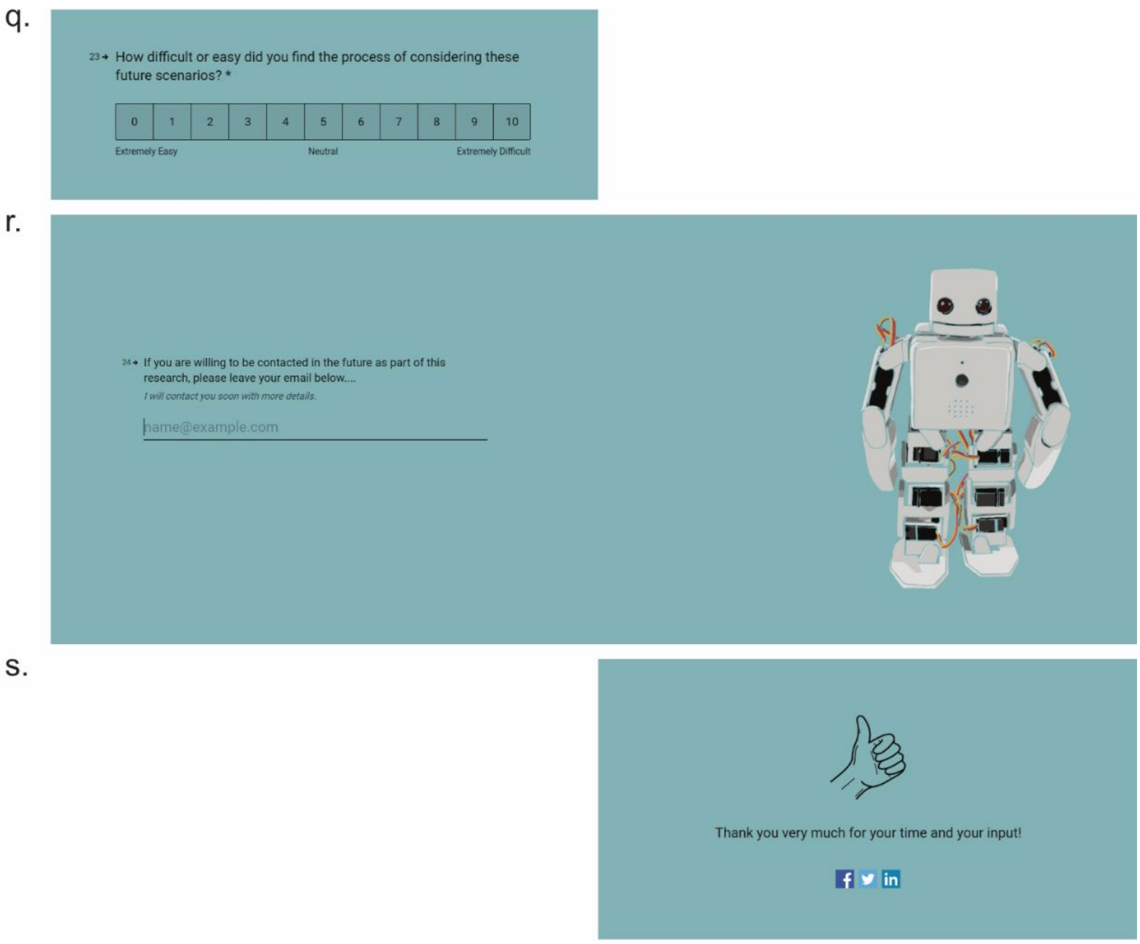


Figure 8.5 The feedback and share screens from the research survey – The final question of the survey representing the 'purple hat', was concerned with understanding how difficult the participants had found the overall process of this research survey. The following screen provided the opportunity for participants to share their email address to receive an invitation to take part in a further stage of this research. The final screen was a thumbs up and a thank you for participating, accompanied by several social media icons that would allow participants to share the survey on their desired platform.

8.5 Releasing it into the Wild

The research survey was disseminated in two ways, the first was a short message that was posted onto social media platforms and the second was an email that was sent out to makerspace, research, and university mailing lists. Once the survey was released, the Typeform platform provided real time statistics concerning participant numbers. Having waited forty-eight hours before logging into Typeform for the first time, it was revealed that 92 participants had completed the survey. Whilst each of the earlier data gathering sessions had shown that people are generally happy to share their thoughts and contribute to this research, this number was still higher than had been expected. The survey was left running live for seven days in total, and at the close there were 146 completed surveys.

One of the benefits of using the Typeform platform was the ability to access the integrated data analysis features, revealing how participants had engaged with the survey. Whilst this was not a primary aim of the research, these insights are nonetheless interesting and can shed some light on how the research survey had performed. At the close of the survey, it had been viewed by 730 people, 463 of which had started the survey and 146 participants had completed it fully. It was surprising to discover that the average completion time was 85 minutes and 30 seconds. It was expected that this research survey would take some time to complete, but it had not been anticipated that people would be willing to invest quite so much of their time to provide these responses. This was taken as an indication that the participants had provided carefully considered responses and had taken the time to study the images, far more so than had been anticipated[14].

In terms of understanding how participants had viewed the survey, 122 responses came from participants using a desktop computer and 24 from those using a mobile device. The completion rate from those who viewed the survey on a mobile device was only 14.9%, with an average completion time of 36 minutes and 12 seconds. This was considered to be confirmation that when viewing the survey in this format, it was a far less engaging and less attractive proposition.

[14] It has been pointed out by the examiners that a trial run of the survey would have revealed some of these flaws. However, due to the impact of the Covid 19 pandemic on this research there were concerns regarding timescales that prevented testing of the survey and its design.

8.6 The Findings

Having collected received 146 completed surveys, there were an extremely wide variety of views shared, and far too many to discuss in their entirety. This chapter will therefore discuss the main themes from each scenario, accompanied by a visual montage that is indicative of the range of thoughts and ideas that were submitted. This is followed by a brief overview of the responses to each scenario and ends with a discussion on the feedback received concerning the research survey itself.

8.6.1 Scenario One – The Near Future Streetscape

The survey began with the Streetscape [Fig. 8.6], the most common response to this was to focus on the potential benefits of being able to repair or recycle a higher proportion of goods, followed closely by a curiosity for 3D printed food. There was a stark difference to these two discussions however, whereas the 3D printed food was mentioned as a point of interest, and something many were eager to try out, the potential for 3D printing to increase the life of products, or produce them in a more sustainable, local manner, was discussed in much more serious terms.

Seemingly the key thing that people 'know' about 3D printing technology, is that it offers the potential to alter societies relationship with material products, by offering the means to manufacture replacement parts that are otherwise uneconomic to produce, or to customise objects for a market of one. One participant commented, "I like the potential for a more cradle to cradle, sustainable future, which I think is part of what 3d printing might offer." There is however a flip side to this, with some expressing their concern that whilst there is this potential for good, the increased access to what is perceived to be cheap local manufacturing, could lead to a rise in consumerism and add to the problems of a throwaway society, with one comment reading, "I would not like too many things 3D printed especially if they were plastic and/or for some quick disposable use. My main concern is ecological." Regardless, the notion that 3D printing technology would play an important role in the future of sustainable living was a recurring theme throughout the survey.

Figure 8.6 A word cloud showing the most frequent words used in response to the Near Future Streetscape scenario, as discussed in this chapter.

There were also many examples of the participants successfully putting themselves within this scenario, developing their own narratives and imagining the wider world surrounding these images. This was evidenced with comments such as, “It looks like there are silos of material in the background perhaps - which is exciting, perhaps people are getting pay per use 3D printing?”; “I'm guessing the FixHub uses 3D printers to repair things. And the Food Ink store uses 3D printers to make food. I like these ideas, but I'm also a researcher in this area so I'm projecting my ideal vision onto them”; “I’m excited by the prosthetics because my dad has really bad knees and with age this is likely going to get worse. So, it would be amazing if solutions could be designed to help people health wise.”

The construction scale 3D printing was also a frequent topic for discussion, with one participant explaining that they "once saw a show about 3d printed buildings. I think some funky buildings could be made - both for shops but also for housing." Another participant shared their expectation for how in the future 3D printing could reduce material waste, stating "In the context of a near future I would like to see recycle centres where old 3D printed structures could be re-processed into raw materials that can be 3D printed infinitely so material waste is significantly reduced."

The choice of scenario was also a frequent topic for discussion, with many participants expressing their happiness that a High Street would still be thriving in the future. Many of these comments also suggested that the real and lived in approach, as promoted by the future mundane approach to visioning, had been an appropriate choice, having received comments such as "it looks like a functioning high street which is a good thing, but the facilities/shops have evolved." And "[w]hat I like about this scenario is that there is an intertwining between familiar high street shops and foot mobility with a more technologically advanced robots and forms of transport. This is exciting and comforting that the technological advancements do not overshadow and dominate everyday life."

Though of course there were also numerous concerns raised by these scenarios, primarily these focused on the suggested prevalence of technology and the possibility of its misuse. Some of these concerns were quite general, such as "[t]he extent to which technologies would become part of our world - particularly considering previous scandals regarding Huawei, etc. would be of concern" with others feeling that this future scenario was "[l]ess desirable because of safety concerns - including the possibility that illegal products e.g., guns could be produced and sold. Also, I'd wonder about the risk of a two-tiered society – 'the tech haves and tech nots'."

Whilst most of the questions in the survey were explorative and open ended, there was one specific question, asked of each scenario, with the specific aim of revealing people gut feelings or reaction to the speculative visions. For the streetscape scene the most popular response was *Interested*, which was selected by 65% of the participants. This question allowed participants to select multiple answers, with the graph below indicating the number of participants who selected each of the emotions. Having analysed the data there were many instances of mixed reactions, such as *Critical–Interested–Optimistic, Confused-Excited-Interested* and *Fearful-Critical-Interested-Confused-Excited-Stressed.* Rarely did a participant respond with a single emotional response, which suggests that the illustrations were eliciting a good level of consideration.

8.6.2 Scenario Two – Near Future Makerspace

The next scenario presented was a Near Future Makerspace [Fig. 8.7]. The majority of the participants responded positively to this scenario, recognising the potential, for what they assumed to be, a community space, and the opportunity this afforded for people to collaborate, access technology, and develop new skills. Participants also started to explain their responses, beyond simply answering the questions, with comments such as "…I'd like to visit this place! So, from the outside streetscape, it seemed much like any other high street - but then understanding visually the inside seems more interesting and exciting. It seems like a very postmodern place to go and get something fixed!" and "I like making and feel that making communities have multiple positive impacts. The idea of making and fixing makes me feel comfortable and excited. This is what resonates with me."

However, alongside this positivity, there was also an unanticipated degree of confusion around this scenario, with some participants not being familiar with the concept of makerspaces and therefore questioning the possibility of such spaces existing, primarily from an economic standpoint. One such comment was "I don't see how this many people will be hired simply to keep 3D printers running and I honestly think that they will decrease the amount of jobs. In my opinion a store like this would be one person having one PC attached to a printer network and they simply need to pass the design to the printer they want. I also find it unlikely that shops like these will exist for long as people will probably adapt to having a 3D printer in the house if they are so useful. They're expensive now but as they become more common more people will adapt to having one around." Others commented that "[i]t looks kind of exclusive - it's probably something only the wealthy or reasonably wealthy will be benefitting from" and "I doubt if it could really happen in the future. But I really like this technology applied in such environment."

Figure 6 A word cloud showing the most frequent responses to the Near Future Makerspace scenario, as discussed in this chapter.

This resonated with the findings from Data gathering session Two, which suggested that knowledge of the Maker Movement has not yet fully permeated into the mainstream, so participants being sceptical of their success is perhaps unsurprising.

A small number of participants simply stated that this kind of scenario was not something they would likely engage with, but for others there were real concerns surrounding the open accessibility of this technology. These concerns primarily focused on the lack of regulations governing what people could produce, with comments such as "There is no monitoring of what people are building.

They might have bad intentions, and this accessibility might allow them to harm the society/others without much in their way to stop them" and "[l]ike I said, not everyone has the best intentions when creating things, and this might make it too easy for people to act upon their intentions."

Despite this scepticism and concern, the majority of participants were either familiar with the concept of a Makerspace or were able to discern enough from the illustration to anticipate how such a space could work, and the overall opinion was that this scenario would be a preferable future. An interesting point to make here is that whilst the participants had not been prompted to do so, many explained that this was their preferred scenario. This created another point of interest, in that many who explained this to be their preferred scenario, also expressed that they would probably not use such a facility but recognised its benefit for others.

When asked to consider their emotional response to the speculative scenarios, once again the most frequent response was *Interested,* which was selected by 72% of participants. In a similar manner there was all also a high proportion of contradictory combinations, such as *Optimistic-Critical-Excited*. One explanation for these types of answers is that rather than treating the illustration as a single composition, participants are responding to specific elements (*visual hooks*) depicted within them.

8.6.3 Scenario Three – Near Future Home Workshop

The final scenario depicted a Near Future Home Workshop [Fig. 8.8], which received the most varied responses. There were many participants who remained positive about this potential future scenario, providing comments such as "I like how much space in the home has been given over to making and fixing as it is something I personally enjoy. I think it benefits this household as thinks like the Dysons can be repaired and resold or given back to their previous owners. I like that young and old are working together, that's really beneficial to both parties" and "This is very idealistic! I'd love this! My whole family could use a space like this for making and fixing." For others however, this scenario was a little disappointing, with one commenting that “there's nothing exciting / new here. once upon a time people tinkered with cars, now they tinker with robots - boring!”

Figure 7 A word cloud showing the most frequent responses to the Near Future Home Workshop scenario, as discussed in this chapter.

There was also criticism levelled at the choice of setting, primarily that this was “not a domestic setting” and that “[t]he robot seems unrealistic, particularly that it would be in such a homely and accessible picture in the next decade - will take 40 years plus”. Not only was there doubt as to the possibility of such a scenario becoming a reality, but criticism was also levelled at the privilege being displayed by such a scenario. One participant commented that “[t]his looks bigger than the ground floor of my house. This future is clearly only for a privileged sector of society.” Another participant simply wrote “Older white dude -> technology accessible to those with a lot of resources already, rather than those most in need.” A thought which was shared and elaborated further by another participant who responded “[t]he level of wealth needed for a scenario like this involves generations of privilege. For the few not the many. Who gets left behind in this country's community? Is this democratic and socialist? Should 3D printing be available to all?”

The primary criticisms for this scenario were its perceived unattainability, given the current cost of living and housing crisis, and that this technology is better suited to a community space where it can be more beneficial for society. This criticism was also once again joined by familiar concerns regarding the potential misuse of 3D printing technology to produce elicit items, such as weapons. Whilst this concern had been mentioned in response to the Near Future Makerspace scenario, being that this scenario was a private space as opposed to a public space, there was a broader range of concerns that were revealed. Some of these concerns centred around the safety and capabilities of the users, receiving comments such as “is this an elderly person fixing his robot helper or carer? or is this an engineer fixing someone else's robot helper? this raises questions of mental capacity, robots who help with dementia and home life etc...” and “[w]hat could people possibly need 3D printers to build robots at home for? I feel like this is a security and environmental risk”. Others were less concerned with what was allowed to happen in a private space, but more concerned with what would be prevented, suggesting that “[r]egulation could hinder the possibility for both the robots and replacement vacuum parts”. Others were concerned about both, questioning “[w]ould local councils allow 3D factories in suburban garages and living rooms. What about the energy required to 3D print all of this stuff? Where would all this stuff end up? What is the stuff for?”

Whilst similar concerns were raised for each of the previous scenarios, though it seems to be that the domestic workshop received the majority of these negative comments due to it being a private space, rather than a public one, so the potential for secrecy is greatly increased. Despite this concern being a common topic of discussion throughout this research, the findings of this survey and the earlier data gathering sessions, alongside the research of others (Jenzen-Jones, 2015; Birtchnell and Gorkin, 2013; Ferguson, 2014), do not suggest that this is a necessary cause for concern.

The most frequent emotional response selected by the participants was once again interested, which was selected by 65% of participants. This was taken as an indication that the graphic social future visions were performing their primary function of being engaging.

The final question asked of the participants [Fig. 8.10] was to rate the ease of the task of considering these future scenarios. The results below indicate that considering futures remains a somewhat difficult subject, however, it is unclear how much this was influenced by the format of the research, or the subject itself, but this matter will be explored further in the following chapter.

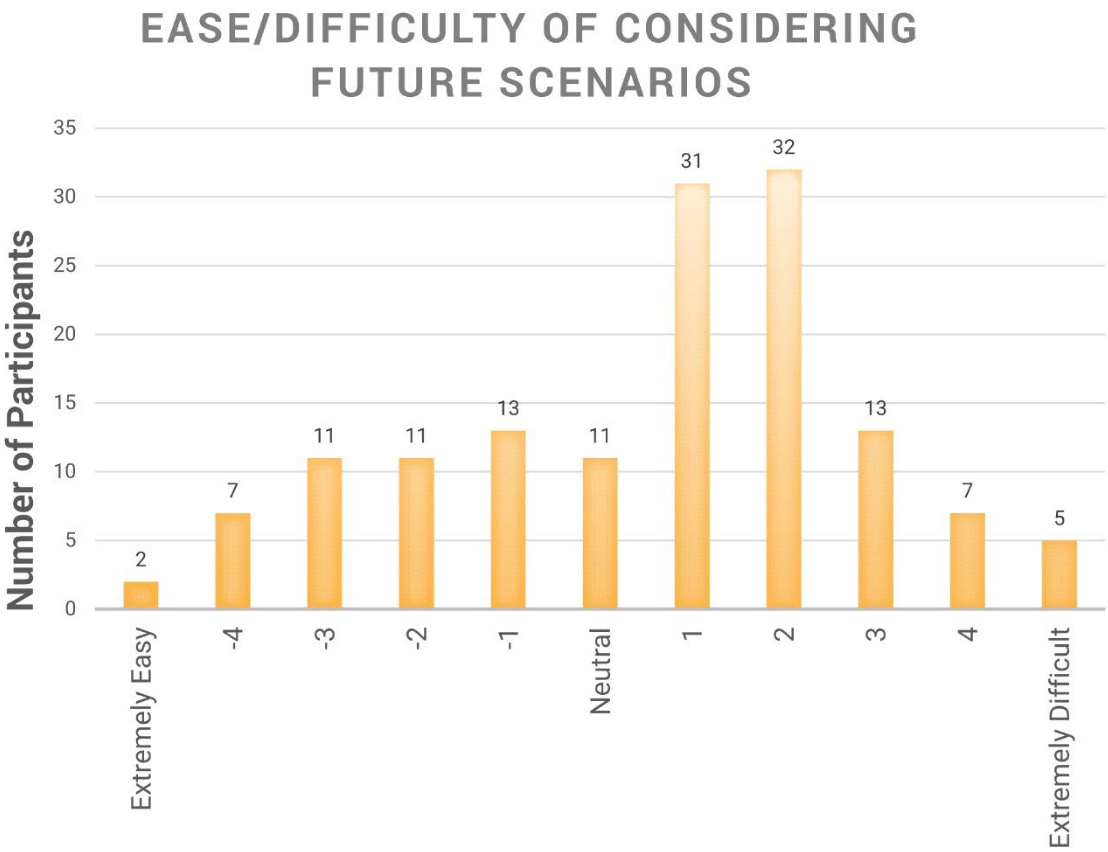


Figure 8.9 The perceived ease or difficulty of 3D printing – This graph indicates the responses of the 146 participants, when asked to rate the ease or difficulty with which they found considering these future scenarios.

8.6.4 Survey Findings

The first step towards understanding and analysing the responses from the research survey, was to transfer the data from TypeForm into Excel, so that the responses could be organised. Each row presented a single participants response, with each column representing the different questions. Viewed in this way, the different responses for each question could be read vertically, or a single participants entire survey response could be read horizontally.

The analysis process began by reading down the column, taking in the responses for each question at a time, making notes on recurring trends and ideas. This was an iterative process, with the responses to each question being read several times to narrow and focus the trends that were emerging. The next step in the process was to read the complete set of responses from each individual in the order that they were received. This provided an emic understanding of the participants responses and further added to the themes and ideas that the survey had revealed. The combination of these two approaches worked well as in some instances the response to one question was referred to in another, or details were recalled which provided much needed context for their remarks.

Having analysed all of the findings in this way, several key trends emerged. The first being that it was seemingly accepted that in the near future, 3D printing will be used as part of our everyday lives. Whilst the extent that each participant expected to use 3D printing varied greatly, there was no outright rejection of the technology, with some even suggesting that the scenarios hadn't gone far enough, stating "I would have liked to see it more integrated in the day to day at home, i.e. not necessarily in the work room, but examples of 3D printing in the living-room, study, den, etc. More integrated in the home." Though there was of course some trepidation concerning its introduction into a domestic environment, such as those who worried about the safety of this practice, stating "I don't like the suggestion that normal people might be able to build their own domestic robot or to repair their Dyson vacuum cleaners."

Secondly, there was far less enthusiasm for 3D printing technology becoming a ubiquitous domesticated appliance than had been anticipated following the responses from the earlier data gathering sessions. There was instead an expectation that should the participants need to engage with this technology, they would do so at a specialist store (or any store, depending on how ubiquitous the technology eventually becomes). One response explained that “it'd be nice if I could send my print job to a drug store or some other retail space and just pick it up” the implication here being that they could use 3D printing without the need to operate it themselves.

The survey responses also revealed the delamination between the expectations of how 3D printing will be used in the future, when compared to the way this same technology is discussed in research literature. Stein (2017) wrote *The Political Imaginaries of 3D Printing: Prompting Mainstream Awareness of Design and Making*, which identified three influential political imaginaries of 3D printing, these were: the *maker-as-entrepreneur*; the *economic revival of the nation’s state*; and *commons-based utopias*. Whilst these varied greatly, they shared one common thing, an ‘increasing awareness of design, making and production’. Despite the stark contrasts in how these imaginaries positioned 3D printing, the common thread was a growing public awareness of design and production, something which certainly aligns with the rhetoric surrounding the maker movement and the press releases of 3D printing companies. However, with the exception of the discussions as part of Data gathering session Three, the discussion around *design, making* and *production* was largely missing from the wider conversations. To be clear, whilst there was much discussion around using 3D printing to make replacement parts or on demand household items, the ‘making’ that Stein is referring to here is the *designing, making* and *production,* as is synonymous with the maker movement (discussed in Chapters Two and Six). However, the way that the majority of participants in this research imagine they will engage with 3D printing are extremely different than the ‘design-make-play learning methodologies’ often discussed by the research literature and are instead what appears to be 3D printing as a service. This resonates a great deal with the thoughts shared by the interviewees from data gathering session three (Chapter Six). They described how in their experience the users of 3D printing technology are often disappointed or uninterested in the process behind 3D printing, such as 3D modelling and preparing design files that are printable, or even the post processing of the 3D printed artefacts themselves. Therefore, whilst there is a high level of interest in 3D printing, this excitement does not necessarily extend to the process of 3D printing itself (and everything that it involves) but is limited to the new potentials that it affords us as consumers.

Whilst the media hype proclaiming how 3D printing will change the world could one day prove correct, this research suggests that this would most likely occur in a manner other than that which is often promoted. Certainly, the messaging concerning the potentials for this technology have permeated into the consciousness of society, with much of the discussions focusing on the ability of 3D printing to replace parts and therefore increase a products lifespan whilst at the same time reducing waste. Though on occasions when the discussion did turn towards the ways in which 3D printing technology could be engaged with, it was seen more as a magical black box that could provide a technological fix to any number of perceived issues (Stahl, 1995). This is perhaps unsurprising considering the language used throughout promotional material and the kind of coverage that 3D printing has received in the press. But rather than understanding it as the transformative technology that the Maker Movement would like it to be, the findings of this research indicate that the majority of people 3D printing as a way of being more sustainable, without having to change their lifestyle. There is the expectation that 3D printing will allow people to produce more bespoke items, support the local economy, save money and be less harmful to the environment, without having to sacrifice existing quality of life.

8.7 Conclusion

Despite complications caused by the Covid-19 pandemic, the data gathering for Data gathering session Four was highly successful in regard to the wide range of views expressed for each of the questions in each of the scenarios, and the duration of time that people were willing to devote to this survey, all indicating that these were well considered responses. The need to carry out this data gathering session as an online activity presented several advantages over the previous, in person, data gathering sessions. Firstly, the participants were able to spend as much time considering their responses as they wanted to, and these responses could be recorded in full. Considering that the average time participants spent completing this survey was 95 minutes, these were very considered responses. The second advantage to this being a virtual data gathering session was the extended reach that this research had, being that many people have access to a computer or smart phone. Thirdly, this data gathering session was not tied to a specific event and so could be carried out over a longer duration. Whilst there were initially some concerns regarding this format for the final data gathering session, the results suggest that the graphic social futures and the accompanying questions had been an effective tool. This was primarily evidenced in the instances where participants responded to a scenario by discussing how they thought their life would be affected, what would it allow them to do and what would their concerns be for this future?

There had also been some concern regarding the scale of the images being presented, but these proved to be unnecessary as the responses showed that all of the primary visual hooks, as discussed in Chapter Seven, had been picked up on. In some instances, this was to discuss their thoughts on what this could mean for their future selves, in others it was to merely express their interest in what this could represent or speculate on what it could be used for.

Overall, the findings do confirm the delamination between the perception of 3D printing as promoted by the 3D printer manufacturers and the maker movement, and the reality of how 3D printing is perceived by those who are not a part of this maker community. These findings also provide a more detailed understanding of the extent of this disconnect.

The narrative surrounding 3D printing as a playful and inventive technology was widely absent from any discussions with the majority of participants. Instead, this technology is understood as a service that could be made available to them, simply a different form of manufacturing an object or artefact that they could buy. Whilst it suits the 3D Printing manufacturers to maintain the myth of this technology as a magic black box, 'Limited only by your imagination' (WSJ, 2013), this disparity is problematic when attempting to discuss an emerging technology that is widely known, but not necessarily understood.

Overall, this data gathering session was successful in that it gathered a great deal of information in response to the graphic social futures, and as the results have shown, the illustrations certainly provoked a response. The most interesting finding however was that whilst it has already been stated that the previous data gathering sessions resulted in rich conversations and discussions during participation, this online survey captured responses that were equally expressive and expansive, despite their being no conversations taking place, being that this was carried out on an individual basis. The illustrations therefore successfully provided the necessary provocations to elicit these responses, and the supporting framework around which the participants were able to construct their own worlds and narratives.

It is not clear from these results however, *how* it performed this task, that is to say, what elements of this methodology did participants best respond to, and which did they feel were ineffective? It is for this reason, those participants who agreed to take further part in this researcher were invited to partake in a recorded discussion, intended to reveal *how* the graphic social futures had performed as a tool to guide people in the consideration of *futures*. The results from these recorded discussions will be the subject of the following chapter, Chapter Nine – Guided Discussion.

9.0 Interviews & Guided Discussions

9.1 Outline

This research has been informed by a series of data gathering sessions, as described in chapters four, five and six, which were concerned with generating data to describe the anticipated and expected use cases for the future of 3D printing. Chapter seven then described the process of using this data, collected from 228 participants, to compose a triptych of alternative social imaginaries for the future of 3D printing. These graphic social futures represent an alternative to the more prevalent "pop" futures (Slaughter, 1989) and corporate imaginaries (Maze, 2019). Producing the visualisations in this manner provides a means of grounding the discussions by providing a framework around which the participants can construct their own worlds (Gaziulusoy and Ryan, 2017a). These alternative imaginaries, functioning as platforms for critical reflection, were then used to generate a research survey, the findings of which were discussed in chapter eight. This chapter discusses the final data gathering session, which was a series of interviews to provide a means to evaluate the efficacy of this research methodology to explore and envision social futures.

This final data gathering session was necessary because whilst the research survey was completed by 146 participants, the survey results alone do not provide a sufficient depth of understanding for *how* specific aspects of these alternative social imaginaries performed. A series of interviews with participants of the survey, however, would provide an opportunity to uncover how their responses had been elicited, which aspects of the image's participants had been responding to, and enable a better understanding of the participants' thought process when engaging with this research. Each participant who completed the research survey was invited to provide a contact email address at the close of the survey if they wished to partake any further in this research. Of those who elected to do so, twenty participants who had provided substantial responses throughout the survey were selected and invited to take part in a recorded interview. This resulted in eleven online, virtually guided, discussions taking place. As the collection of demographic information from the participants had not proven useful in previous data gathering sessions, no efforts were made to capture the participants demographics, though judging by the conversations that took place, this group included both makers and non-makers.

This chapter presents the findings from these interviews, which are explained using three primary themes, which are *Representation*, *Optimistic Scepticism* and *Future Utopias*. These themes were decided upon following thematic analysis of the interview discussions, with each primary theme being comprised of secondary and tertiary themes. The process by which these themes were decided will be described and these themes will be explained in detail in the following sections. The findings mentioned here are those which were determined to be key points for discussion. These findings reveal several key challenges, these are discussed in greater detail along with suggested solutions in the following chapter.

9.2 Understanding the Interviews

The format of the interviews was an informal discussion, not only did this closely resemble the original pre-pandemic plan of a guided public discussion, but it was also hoped that it would provide insights and perspectives that would not otherwise be revealed in a highly structured format, by providing the interviewees the freedom to lead the discussion. Whilst a public discussion was originally chosen as a means to receive a wide variety of views and opinions on the presented social imaginaries, the forced shift to an online platform proved highly successful in collecting a wide range of responses. These guided discussions, in addition to the survey results, provide a much deeper understanding of the responses and allowed the participants to discuss and describe their individual social imaginaries in greater detail. The discussions resulted in over fourteen hours of recorded discussions, which were then transcribed, analysed, and coded, using the qualitative data analysis software *NVivo*. This was done by first analysing each of the interview transcriptions using the 'Auto Code' function to reveal a series of nodes, which represent themes, concepts, ideas, opinions, and experiences that were frequently discussed. This returned results such as Robot, Technology, Industry, Parts etc, and whilst these correlate with the findings of this research regarding the future of technology, these aren't considered themes for the wider research, as these are too narrowly focused on singular ideas or objects. As Virginia Braun and Victoria Clarke (2006) explain, a theme captures something important in the data in relation to the research question, therefore the number of instances of each node does not correlate to its importance, instead the researcher's judgement is necessary to determine what a theme is.

The process of deciding upon the themes for this evaluation stage of the research used affinity mapping, which involved multiple read throughs of the interview transcripts, searching for statements which revealed repeated sentiments, as opposed to repeated words. The fourteen hours of recorded discussions and its subsequent analysis resulted in themes relating to a range of topics, such as 3D printing, technology, futures, hopes and fears. The findings of data gathering session four have already been discussed in chapter eight, though to some extent each of these discussions did further elucidate the participants responses regarding their expectations for the future of 3D printing. However, being that this chapter is concerned with how participants engaged with the alternative graphic social imaginaries; the findings discussed here are only those which relate to social futures. The remaining themes were then carefully considered and combined into groups of related sentiment, these could be complimentary or opposing, which resulted in the creation of three primary themes: Representation, Optimistic Scepticism and Future Utopias.

Over the course of this chapter each of the primary themes will be explained through a discussion of the secondary themes. Each primary theme resulted from the detailed analysis of the discussion transcripts, this in turn resulted in several themes which were then grouped into related sentiments, as described by figure 9.1 below. The first round of groupings created the secondary themes, these were then grouped further to create the primary themes. Aspects of the tertiary themes will also be highlighted in relation to the relevant secondary themes.

Primary Themes:	Secondary Themes:	Tertiary Themes:	
Representation	Race & Ethnicity Gender & Stereotypes	Race Ethnicity Gender Age	Disability Privilege Makers Non-Makers
Optimistic Scepticism	Hope for Change Sceptical Optimism	Economy Innovation Creativity Job Loss Unregulated	Opportunity Loss Enabling Convenience Consumerism Weapons
Future Utopias	Utopian Futures Spectacular Futures	Concern Expectations Positivity	Benefits Criticism

Figure 9.1 A table of the Primary Themes - These were decided upon following detailed analysis of the interview transcripts, and the respective secondary and tertiary themes that each of the primary themes are comprised of.

9.3 Theme One - Representation

The importance of appropriate representation, especially those concerning ethnicity and gender, have risen to the fore of media and social discourse (Brooks and Hébert, 2006; Orgad, 2012; Talbot, 2007; Moscovici, 2001). In addition to this, the research survey and subsequent interviews that are being discussed here, all took place at the height of the Black Lives Matter protest, with marches and protests taking place around the globe (Rickford, 2016; Sobo *et al.*, 2020). It is anticipated that this will have had an impact on the findings of this research. Though, that is not to say that this matter would not have arisen regardless, or that it would be considered any less important. It is however important to consider this when understanding these findings.

9.3.1 Race/Ethnicity

The first theme, Representation, emerged as an important issue very early on during data gathering session four, prior even to the analysis taking place. A participant who had just completed the survey made contact via email to explain that they had *"put in a few semi-snarky comments about the* *overwhelming whiteness of your depicted figures"*, and *"Since you're asking about "comfort" and such, it's worth considering whether a person of colo[u]r (particularly a woman of colo[u]r) would feel "comfortable" in those scenes…"*. As has been discussed in chapter seven, in response to the findings of the Strange Telemetry government report, *Speculative Design and the Future of an Aging Population* (2015a), the manner in which people were to be depicted within the illustrations was a significant decision. Strange Telemetry explained the importance of populating the images with people, as they themselves chose to exclude any depictions of people in their artefacts as a way of avoiding promoting stereotypes, however, this led to *"constant critiques across all groups that the scenes seemed empty, unfriendly, and perhaps even under some sinister dystopian control" (ibid.)*. Their suggestion to overcome this issue, whilst still avoiding reproducing stereotypes, was to populate the image with abstracted people. Whilst this approach was initially considered for the illustrations, to do so would have undermined the illustrations' ability to bring these issues to the fore. These graphic social futures are not attempting to present another commercial vision of future technology, featuring the optimal range of diversity, representation, and equality. They are instead presenting more likely futures, featuring new technologies, but based on projections of the current data and representation within these spaces. It is this presentation of more realistic, lived-in futures, that provokes debate about what sort of futures we want to see.

As discussed in chapter seven, it was also important for this research, that the illustrations be composed of realistic elements to create a grounded representation of a future reality, therefore each component of the images were influenced by current and existing scenes. As Dunn and Cureton (2020b) point out when discussing visions for future cities, the very act of presenting and promoting certain aspects of urban life, means that a vision necessarily must either purposefully or subconsciously omit others. It was therefore decided to include these people within the illustrations as they are representative of the existing users or visitors to these types of spaces, particularly those found in the Northwest of England.

The issue as described by the participant had arisen because their expectation for what diversity should look like was based on their experiences of very different contexts and cultures (Esteban, 2015; Ranasinghe *et al.*, 2018). The illustrations depicted scenes set within a Northwest, English town (as shown in figure 9.2), populated by a typical demographic of people, whereas the participant was from the American city of Michigan. Amongst the survey responses several similar comments were found from participants hailing from different corners of the globe. Whilst the need for representation had been considered an important factor in this research, the conversations that took place during the interviews revealed that the importance of this for successful immersion into the scenarios was greatly underestimated. Had this issue been better understood and anticipated prior to the survey being released into the wild, an explanation would have been included at the outset of the survey explaining that these particular graphic social imaginaries are intended to be geographically located and are therefore both culturally and demographically specific [15].

[15] Suggestions for how this issue (and others) could be resolved are discussed in the following chapter, section 10.4 Recommendations.

Figure 9.2 Scenarios depicting a North West England location – Whilst efforts had been made to populate each scenario with depictions of people that were representative of existing users and visitors to these spaces, the range of demographic received criticism from participants who were not located within, or familiar with the North West of England, which was the chosen setting for each of the scenarios

9.3.2 Gender & Stereotypes

One of the interviewees (a male that works in a Makerspace) raised the issue of gender almost immediately when discussing the future Makerspace scenario. He explained that whilst the illustration did have a mixture of people, it was skewed towards being male dominant, which as he explained, is something that these spaces are often known for. It should be pointed out however, there was an awareness of the ongoing discourse around gender representation when designing these graphic social imaginaries, though the full extent of this issue was admittedly underestimated. By taking inspiration from photographs of similar spaces, photographs which were both taken personally and gathered from online sources, this research was creating accurate representations of the existing users of these spaces. What was not understood by this research, however, was the importance of the roles that these people played within the scenes (Gunnarsson-Ostling, 20011; Brooks and Hébert, 2006). It was highlighted by many of the interviewees during the discussions that there were very few representations of women being the active participant in using the technology, they were more commonly depicted as part of the background or were being taught how to use the technology by an 'older white male'. This research would argue that the graphic social futures this research presented are holding a mirror to reality, and therefore the criticisms raised towards these graphic futures, such as low diversity makerspaces, indicate and illuminates issues that we can consider in the present, to work towards changing this outcome.

The findings of this research suggest that appropriate representation for the target audience is of great importance, to succeed in the social construction of new imaginaries (Maze, 2019). Deciding upon what constitutes appropriate representation is one of the challenges to producing graphic social futures, as this varies widely depending on the geographical location of the intended audience. For the scenarios to be successful as scaffolding around which each participant could construct their own future reality, each participant must be able to engage with the scene. The entry points into these worlds were provided by the visual hooks, and whilst these proved to be effective, the participants also needed to be able to relate to the scenarios on a personal level, most commonly the participants expected to achieve this through representation within the scenes. This was perhaps best summed up by one of the interviewees, who stated:

> …so you have the prompt at the start and then you'd have an asterisk underneath with the tip. And the tip was, to not pay attention to the people or the aesthetics. I found myself asking myself time and time again, how is that possible? We can't. You can't not do that. It's how we access that vision that you're giving us, because we're humans we look for humans and we automatically think and understand the contents of that visualization through the aesthetics, so I could see that you really wanted us, not to focus on that. But I would say that that's always going to be impossible for anyone engaging with it.

Despite the participants being asked a series of specific questions to guide them through the graphic futures, they were unable to consider the future scenarios, without first understanding the social human context. That is to say that, if the viewer was unable to recognise themselves within the presented scenario, or if it did not sufficiently align with their expectations, then it became almost impossible for them to successfully inhabit the scenario. There has been a growing discourse surrounding this issue, with examples of alternative cultures achieving mainstream exposure, such as Afrofuturism as portrayed in the 2018 Marvel film *Black Panther* (Winchester, 2018; Strong and Chaplin, 2019; Ritzenhoff *et al.*, 2021). Upon reflection this seems quite an obvious idea to have overlooked, considering that representation is closely tied to identity and the production of culture, which are influential factors for the social imaginary (Taylor, 2004; Hall, 1997). There is a careful balance to be struck then, when composing the scenarios, whilst efforts can be made to make it as fair and balanced as possible, there is always the risk of producing a misleading and overly optimistic image of reality, though there is certainly more that could be done to ensure that the marginal constituencies are made more visible.

The issue of appropriate representation in future visions is a known problem, an early example of this is the criticism levelled at the influential avant-garde architectural group Archigram. Despite an increasingly diverse population and their sharp awareness of culture, they broadly overlooked the importance of representation (Dunn and Cureton, 2020b). When discussing the visual outputs of Archigram, Sadler (2005: p.183) stated: *"Mostly absent was anyone working, elderly, ordinary, or non-Caucasian (…) so the issue of representativeness successively went beyond gender to encompass age, class, and race."* Their failure to react to the "wider shifts in inequality across society" (Dunn and Cureton, 2020b: p.120), ultimately contributed to their demise. More recently it has been noted that visualisations of UK future cities feature largely generic built forms, as opposed to identifiably British ones. Dunn et al, explain that:

> This development is emblematic of wider processes of globalisation and interconnectedness through digital technologies and raises questions on urbanisation, identity and 'place' making and debates of homogenised urbanism. (Dunn et al., 2014: p.109)

9.3.3 Depth and Resolution in Futures Revisited

As has already been discussed in Chapter Two (p.79), this research posits that in terms of resolution, a successful graphic social future must be sufficiently realised as to provide a rich experience for the audience, but also sufficiently porous, providing multiple entry points to effectively support the audience in further constructing their own imaginaries around them. Graphic social futures are therefore positioned between the hyper detailed worlds depicted by "pop" futures, and the vague acontextual worlds as depicted by corporate visioning. Successfully achieving this balance is one of the key challenges to producing graphic social futures. Although they each contain multiple visual hooks, acting as entry points into these worlds, these are not fully resolved so as to be more easily adopted and considered by the viewer. This results in future visions which are highly situated and contextual, which can therefore only represent the range of cultures and demographics, that is most appropriate for the target audience. Omitting or reducing the contextual details would result in visioning that is more akin to the lesser resolved problem-oriented futures.

The difficulty of this careful balancing act was discussed during several of the interviews, with one participant making the point that:

> You can make it as fair and as well balanced as possible and as accurate as possible, but one of the problems with the sort of the white washing or the kind of gender imbalance is it produces a false image…

Discussions around this theme most frequently centred around the Makerspace scenario [Fig. 9.6], though one participant had very strong views concerning the idea of engendered spaces, stating:

> There are all these wider frustrations because there's no reason why any woman would get to the door of this lab and think I can't go in there because I'm female. I can talk quite confidently from that point of view.

Aside from the discussions concerning representation, another important point was raised by one interviewee who explained their viewpoint on the accessibility of *makerspaces* and the idea of democratised technology, as:

> What cannot hold is the idea, therefore, that these spaces are democratic in the way that they purport to be. They are fantastic if you have the skills. If you don't have the skills, they are closed off because we don't understand what they're there for, don't understand what's happening in how they can be used, and if you don't have those skills to start with, it's just a huge barrier to getting involved… The tools on their own will not give you skills. It takes time, you have to acquire them over time and with the right resources and with the right support… Then you can start talking about kind of what makes a space open and democratic.

These conversations led to the realisation that the scenarios that had been presented, to some extent had fallen foul of merely reinforcing several common stereotypes, which have already been highlighted and discussed in the previous chapters. This issue has also been discussed by Fredric Jameson (2013, p228), who stated that “our most energetic imaginative leaps into radical alternatives were little more than the projections of our own social moment and historical or subjective situation.” It would therefore seem appropriate to suggest that future efforts to create graphic social futures should first identify existing relevant stereotypes. It can then be considered how to indicate that progress towards eliminating these issues has been made. It is important to not merely whitewash these problems away, as it is the social structures and practices of today which are perpetuated into the future and therefore cannot simply be ignored. Using graphic social futures in this manner could be a useful tool for probing flawed futures, exploring issues such as race

(Winchester, 2018; Skinner, 2006), gender (Swan, 2010) and sustainability (Holling, 2000), exposing challenges and problems, to provoke meaningful discussions about how we can make positive change.

Figure 9.3 A Near Future Makerspace - Whilst many people were excited at the prospect of having access to such a space, it was pointed out by several interviewees that more effort was needed to ensure a more equitable balance of gender, race, ethnicity and age, as active participants in this scenario, rather than merely being spectators.

9.4 Theme Two - Optimistic Scepticism

The second theme is comprised of two interconnected, but seemingly contradictory ideas. It was not uncommon for the responses from a single participant to be both optimistic, describing the possibilities of a future with ample access to 3D printing technology, but then also sceptical, providing a slew of reasons that this future would not become a reality. Though 3D printing was used as the driver for change in this research, the manner in which the participants discussed this dichotomy suggests that this response would be applicable to the wider discourse on futures and technology. This duality is the subject of the theme two.

9.4.1 Hope for Change

Throughout the interviews, conversation turned to the optimism surrounding 3D printing technology. As has already been highlighted in the survey responses, the potential benefits of 3D Printing technology in terms of reduction of material use, production of replacement parts to prolong product life and the opportunity to recycle plastics etc. are all seemingly well known. One interviewee described that they felt; *"Optimistic because I think it always is good that we're moving forward from a sort of situation that isn't particularly good in a world format."* All of the interviewees to some extent discussed the need for changes in behaviour and attitudes towards consumerism and the lifecycle of products, recognising and explaining how they believed 3D printing could play an important role in affecting this in a positive manner. In many instances, these statements that something needed to change were strongly held beliefs, not merely suggestions of how things could be improved in the future. They were also large scale, global issues that were being suggested, such as climate change, pollution, and an over reliance on large corporations. Tackling these issues was discussed as a necessity, with 3D Printing seen to some extent as a solution to a number of these problems. Throughout these interviews, and each of the preceding data gathering sessions there was a prevalent belief in technological determinism, and that technology would provide the solution to our biggest problems (Marx *et al.*, 1994). Considering the rhetoric surrounding 3D printing technology (Smith, 2017; D'Aveni, 2013), this is hardly surprising, though the extent to which hope was being placed on technology providing solutions to our problems, as opposed to enacting social or behavioural change, was surprising to hear first-hand.

9.4.2 Sceptical of Change

Much of this optimism, for 3D printing as a solution to societies major challenges, however, were quickly followed by a number of reasons why the interviewees thought that this would not ultimately happen. Therefore, the second theme is referred to as optimistic scepticism. As has already been stated there was seemingly the acceptance of technological determinism, the mechanism by which complex events, such as the shift to zero waste production and consumption, are the plausible result of a technological innovation (Marx *et al.*, 1994). At the same time however, the participants were quick to point out reasons why these changes would likely not be achieved. Whilst there was a high level of hope and optimism surrounding the potential of 3D printing, this seemingly also aided in the interviewees ability to identify barriers to achieving this. Reasons for the potentials of 3D printing that were discussed not being achieved ranged from economic, to political, to financial and cultural. The primary barrier being the attitudes and culture of a consumerist society, with the acknowledgement that technology has the power to disrupt, but as the participants suggested, only if people are willing participants in the process. As one interviewee put it:

> They've sold it kind of optimistically looking at the end product, all the things you can do and kind of just skips over the actual process of getting it done. Can you find the materials? Have you got the skills?

The conversations covered an extremely wide range of reasons that 3D printing might not deliver on its potential, ranging from economics and politics, with one interviewee stating: "… I feel kind of sad that I feel that that won't maybe happen because economics tends to take over everything within our political arena that we're in at the moment." Another interviewee, discussing their hopes and concerns for 3D printing, similarly stated:

> I wonder to what extent that will play out in reality, because I think that's one of its greatest potentials, it stops us from being reliant upon massive corporate companies that are ruining the Earth, not respecting human rights and worker's rights etc. And sustaining and continuing massive geopolitical traumas, but I wondered to the extent to which the people who are living that present day Utopia of the Makerspace, and thinking about what it will be, is this a kind of commonly held kind of good?

As 3D printing was being used as the vehicle for creating and discussing graphic social futures, the details and the focus of the images were restricted to the potentials, expectations and anticipated use cases that had resulted from the initial three data gathering sessions. The process of socially constructed graphic social futures proved to be highly effective at not only highlighting peoples expected use cases for 3D printing technology, but also revealing the challenges and barriers that are currently, or in the future, could potentially prevent the successful adoption of this technology, which suggests that this method could be effectively applied to other emerging technologies. Efforts had been made in each of the scenarios to include visual hooks that would indicate progress towards more sustainable approaches in the future, such as plastic recycling bins in the streetscape and the FixHub repair shop in both the streetscape and makerspace. As has already been discussed, the visual hooks proved to be highly effective entry points into these futures, so much so that many participants used the opportunity to discuss a wide range of topics, sometimes only tangentially related to the illustrations. A popular example of this was in response to the inclusion of robots and drones in each of the scenarios (as a result of their popularity in data gathering sessions one and two), which provoked a great many participants to express their fear and concern for the future of AI technology. This suggests that further work could use this methodology for creating socially constructed imaginaries to create richer graphic social futures that explore some of the wicked problems that society faces, such as poverty, climate change, sustainability etc, and other emerging but potentially problematic technologies, such as A.I.

9.5 Theme Three - Aspirational Futures

For some participants however, these near future scenarios were far too mundane and unambitious, and as a result some participants found it extremely difficult to engage with the presented scenarios. Whilst the survey results had already indicated that some found the future mundane approach to be a little underwhelming, the interview conversations offered far more insight into why this was the case. Put simply, there is a certain level of expectation for future scenarios to be utopian and more spectacular, as is the case in many examples of “pop” futures. It is for this reason that the third theme is referred to as aspirational futures.

9.5.1 Future Utopia

Just as there were those participants who found the near future approach to be relatable, there were those who were expecting of something much more aspirational, futures in which the problems of today had already been solved. The primary criticism towards the scenarios as presented, was that they indicated that society had failed to solve some of the major problems that we face today. The participants therefore viewed these future scenarios as representing a failure to act, whereas they were in fact expecting and hoping for aspirational and more utopian representations of future scenarios that could offer us something to strive towards (Snyder, 2000). One interviewee explained that they were:

> … hungry for visualizations that take us away from business as usual and the normal and try and push us into thinking about the ways in which we're going to have to be thinking and living in, even in the near future. The same interviewee went on to explain that; When it comes to issues of Environmental and climate change, migration etc., my disappointment was, in the scene that had the rubbish bin with the recycling sign on it, it's like right, we're still dealing with that kind of issue are we?

By the interviewees own admission this was an emotional response to the realisation that this was not showing them the Utopia they were craving, though this did lead them to consider how 3D printing might actually serve some of their desires for utopian futures by impacting some of the major changes that climate change is inflicting upon us now and will do so in the near future (Gaziulusoy and Ryan, 2017a). The inclusion of these mundane artefacts as visual hooks forced them to confront the challenges of today and consider how change might be brought about to combat what they perceived to be these major challenges. This points to the success of these graphic social imaginaries to assist people in considering the future and represents a key finding of this research.

Others were even more critical of the future scenarios as presented (for example figure 9.7 below), stating "it was critical because it almost felt like dystopian […] I don't know if you have read any William Gibson, the environment in the background and all the structures were very familiar, yet you had those mixes of Androids." The scenes were based on existing streetscapes and spaces, it therefore suggests that this criticism arose because there was an expectation for a much greater degree of change to be exhibited. These comments bear a great deal of similarity to those expressing a hope for change in the future, such as: "…it's kind of back to that first image, it just seems to reinforce current modes and current trends of, we will still consume like this, we will still make and throw away bits of novelty…”. The difference here being that for some it is much more than a hope for a ‘better’ future, it is the expectation of one. Whilst the extent that participants would be expected a utopian future had not been anticipated, their disappointment at a less than utopian future did not necessarily prevent or diminish engagement with the scenarios. The issues that were raised and the criticisms levelled at the scenarios still revealed wider concerns for the future. This therefore suggests that by pushing back against the portrayal of utopias and presenting a future which is still very much a work in progress, the visions are highly successful at eliciting from participants what changes they are expecting to see in the future and which of today’s problems they are hoping will be resolved.

Figure 9.4 A Near Future Streetscape – The large format/construction scale 3D printer in the background was recognised by several interviewees, which triggered their recollection of the first time they discovered this technology in real life. The recycling logo on the bin on the right was another detail picked out by an interviewee, though this time it was to express their disappointment that the issue of material waste and recycling was a problem that had yet to be solved in this future.

This idea of presenting future visions that represent a work in progress, rather than a fully realised Utopia, contributes to the ongoing debate concerning the positioning of utopian visions as a method, rather than a goal. Levitas (2013a, p. xi) explains that "the core of utopia is the desire for being otherwise" which Jameson (2013, p.416) elaborates further by explaining that "[u]topia as a form is not the representation of radical alternatives; it is rather simply the imperative to imagine them." The expressions of utopian visions "explore and bring to debate the potential contents and contexts of human flourishing" (Levitas, 2013a, p. xi). The use of graphic social futures, in this research, has facilitated engagement with the public to reveal their desires, and what they consider to be a better way of being or living, by presenting visual examples of what Levitas refers to as "mundane or everyday utopianism" (ibid, p. xiii). The graphic social futures as presented by this research are therefore comprised of both the visual elements that have resulted from participant engagement, and also the ideas around utopian thinking that have been revealed through the discourse enacted by participants engaging with these alternative imaginaries.

9.5.2 Spectacular Futures

For others, even a future wherein the problems of today had been solved, was underwhelming, they were instead much more expectant of a sci-fi fantasy laden future for 3D printing, as promoted by the media, much like the responses gathered during data gathering session one. The near futures as presented by this research are much more grounded, and whilst they do include many elements that are informed by the initial data gathering session, such as 3D printed robots and cars etc, this grounded representation was disappointing to some. One participant commented that; *"[w]e've been absolutely spoiled by expecting, kind of perfection in everything and we are not willing I don't think, kind of behaviourally to go back to the time where failure and imperfection where the norm."* This sentiment was shared by another interviewee, who commented that:

> People are showing a need for something, without knowing what it is that they need, so they've got something that seems really appealing and desirable. But actually, it's a bit cloudy and fuzzy as to what it might be used for, the only point of reference being sci-fi,

which is fiction, which is only ever meant to be fiction. There's something missing because we are in the realms of fantasy until it becomes functional.

This research suggests that whilst a more mundane approach to future scenarios is an effective method for revealing and understanding people's expectations and anticipations for the future, this approach is not necessarily something that the majority of people feel familiar or comfortable with as it faces reality in its grounded representations rather than fiction. This would seem to be especially true for near future visions because each of the scenarios were based on existing scenes but were viewed to be too pessimistic or dystopian. This suggest that there is an expectation for future visions to present a 'better', more advanced world, regardless of the projected timeframe, or how realistic this may be. This does, however, once again raise the question "what does preferable mean, for whom, and who decides?" (Dunne and Raby, 2013: p.4).

The findings of this research suggest that whilst there are extremely varied views on how social futures could unfold, there are certainly a number of widely shared expectations for what these futures should include. The difficulty arises in striking the correct balance between accurate representation, and overly optimistic representation or whitewashing. The same is also true for the theme *Optimistic Scepticism*, once the wicked problems of the day have been identified, details can be placed within a future scenario that hint towards these problems having been solved, or certain details can be removed (such as a recycling logo on a waste bin), that would otherwise suggest there is still a problem. The final theme, *Future Utopias,* however, is a more difficult problem to account for, being that the expectations for what makes a future Utopia is extremely subjective, and expectations can be informed by any number of existing social imaginaries (Wright, 2015; Goode and Godhe, 2017; Levitas, 2013a).

9.6 Conclusion

The graphic social futures that resulted from this research have proven to be highly effective tools for engaging the public in *futures* and revealing what they expect from social futures. Whilst a direct comparison with the initial three data gathering sessions is not possible, due the different approaches to questioning that were taken, the introduction of speculative illustrations into the fourth data gathering session resulted in richer discussions and supported the public in exploring the benefits and potential issues that could arise from the futures that they had imagined. The participants were much more able to discuss the wider implications of a future world with widespread access to 3D printing technology. This led to many instances whereby the hopes and fears concerning futures, but not related to the questions or this research, were revealed. This is of course due in part to the accompanying questions being less focused on the technology itself and more so on what the experience of being in these scenarios would be like. Though this can also be considered evidence that the graphic social futures were successful in providing a framework to support the participants in constructing their own, highly resolved imaginary worlds, which enabled them to explore these wider issues. By providing the visual context alongside a range of questions, the participants were far more inclined to elucidate further on their thoughts, and the rationale behind them, unprompted. They were also able to discuss their ideas and concerns in a high level of detail, describing well fleshed out scenarios and speculative events that explained the thought process behind their responses.

The analysis of the resultant interviews, discussions and survey responses also reveal several key findings for futures research using social imaginaries. Despite the illustrated scenarios being informed by the expectations and anticipation of the public, which had been gathered through data gathering sessions one, two and three; when presented with the resultant visions, participants frequently expressed that they did not align with their expectations of the future. In some instances, this was due to certain things being missing from the illustration, such as a specific piece of advanced technology that they were expecting, e.g., 3D printed hoverboards. More often however, this misalignment was caused by the inclusion of a detail, which indicated to participants that certain social structures and practices had perpetuated into the future (Gunnarsson-Ostling, 20011; Gilleard, 2018), e.g., male dominated technology spaces. This research considers this to be holding a mirror to reality, and therefore the criticisms towards low diversity makerspaces etc., are important current issues that people expect to be tackled. As has been discussed in chapter seven, these graphic social futures were carefully curated with the intention of anchoring them in reality to create meaningful but relatable alternative social imaginaries, in contrast to the more prevalent fantasy inspired science fiction imaginaries (Johnson, 2009; Bell *et al.*, 2013). In practice, regardless of whether the participants felt the presented futures did or did not align with their expectations however, the graphic social futures performed as intended and generated valuable information and insights into what the participants did expect and anticipate from a future where, in this instance, 3D printing is an everyday technology. These images enabled and encouraged the participants to ask questions of the near futures, revealing important social concerns, such as the current lack of diversity in these spaces for example. This was in contrast to previous data gathering sessions where there was an unquestioning acceptance that 3D printing technology would be successfully adopted and diffused into society, and there was no mention of, or consideration for any potentially negative impacts that this could have. The addition of future visions exploring these same ideas prompted participants to question *how* this could, and even *if*, this should occur. This methodology could therefore be suitable for further research that explores some of the wicked problems that society faces (Sheppard *et al.*, 2011; Gaziulusoy and Ryan, 2017a), such as poverty, climate change, sustainability etc.

In relation to this, the near future setting also proved to be highly effective at uncovering the challenges and barriers that participants anticipated the successful adoption of 3D printing technology faced. This research considers that this was in part due to the real-world approach, whereby participants were able to position themselves within the scenario and speculate on how this would affect their everyday lives. However, for others, this same setting of a grittier more realistic near future lacked the ambition of what they were expecting from a speculation on the future. This would seemingly suggest that there is a ‘sweet spot’ so to speak whereby the timeline is sufficiently advanced enough that identified issues of today have had time to be resolved, but not too distant into the future that it becomes difficult for participants to place themselves within the scenario. The role of the designer in this process is therefore to understand the context that they will be working in, in terms of location, demographic, timeline etc., to compose alternative social imaginaries that are sufficiently balanced in their portrayal of the future. This research chose a near future timescale because of the difficulties associated with considering futures (Robinson, 1990), which understandably become more acute the further forward we project into the future. To counteract this problem, the backcasting technique could be used to create multiple graphic social futures at 5- or 10-year intervals, showing how each scenario evolves over time. Participants would then be able to identify which stretch into the future they are comfortable with, what they can accept as credible, and at which point it breaks their suspension of disbelief and enters fantasy. Though this would add a substantial amount of time to the overall process, which is not always possible.

This research has used questions around the social futures of 3D printing as a vehicle to test out the efficacy of graphic social futures which are themselves socially constructed. The results have not only shown that that there is a great deal of confusion surrounding the capabilities and potential future uses for 3D printing technology, but this research would also suggest that the influence of existing social imaginaries as promoted by the media and technology corporations, is widespread and there is a clear expectation that 3D printing will play a role in our future everyday lives. Though it is reasonable to believe that this process could also be used to explore *futures* around other emerging technologies which are poorly understood by the public, such as Artificial Intelligence for example. The impact of this has been the expectation that technology will provide the solutions to the problems of today, which has the effect of raising people's expectations for the future (Pîrjan and Petroşanu, 2013; Smith, 2017; McLaren and Markusson, 2020; Kurzweil, 2014). This resulted in some criticisms being levelled at the scenarios, with participants describing them as falling short of presenting a Utopia, or at the very least a more spectacular future. Whilst a great deal of time and effort went into trying to achieve an appropriate balance of *Plausible*, *Possible, Probable* and *Preferable*, the expectations of the participants were often for examples of *Preferable* or even

Preposterous social imaginaries (Hancock and Bezold, 1994; Voros, 2017). The frequent pop culture references that emerged throughout each of the data gathering sessions, such as 3D printed hoverboards and robots, further demonstrate the impact and influence of existing *vapourworlds* and sci-fi/fantasy driven social imaginaries (Rose, 2017; Maze, 2019). This demonstrates the potential value of providing alternative imaginaries for social futures, as this research has shown that these more grounded futures are a successful means of engaging with the public and facilitating conversations around *futures*.

In terms of resolution then, a successful graphic social future must be sufficiently realised as to provide a rich experience for the audience, but also sufficiently porous, providing multiple entry points to effectively support the audience in further constructing their own imaginaries around them. Graphic social futures are therefore positioned between the hyper detailed worlds depicted by "pop" futures, and the vague acontextual worlds as depicted by corporate visioning. Successfully achieving this balance is one of the key challenges to producing graphic social futures. Although they contain multiple visual hooks, acting as entry points into these worlds, these are not fully rendered to be more easily adopted and considered by the viewer.

10.0 Discussion

10.1 Introduction

The aim of this research was to develop a methodology for the creation of graphic social futures, which are themselves socially constructed – having been informed by the ideas and thoughts shared by the participants in this research – to act as platform for the public to engage with futures research. By doing so, this research situates itself in the deepest level of futures thinking and seeks to reveal our underlying social structures in order to question what makes a good society.

In this instance, it was the social futures of 3D printing technology that they were being asked to consider. The findings of this research indicate that these graphic social futures were successful in providing a framework to support the research participants in constructing their own imaginary worlds, which proved to be an effective method for aiding the public in the discussion and consideration of *futures*. This chapter reflects on the performance of these graphic social futures, which will be carried out through a discussion on the interpretations and implications of the findings, the limitations of this research are then discussed, followed by recommendations for further research in this area of *futures* studies.

10.2 Interpretations & Implications

The findings suggest that there are three key elements that were responsible for the success of the graphic social futures. The first element is – shared visions– with the speculative visions providing a shared platform, which acts as a focus for the participants to consider and discuss *futures* (Lockton and Candy, 2018). The second element is the – grounded and accretive style of the scenarios – which are used to produce scenarios that feel familiar and approachable (Foster, 2013). The final element is the accompanying questions, inspired by the Six Thinking Hats approach to critical thinking (De Bono, 2016). There is then a discussion on two questions that were raised in Chapter One, and are now worth revisiting, these are; futures that are preferable for whom? and what could social futures look like? Each of these will be discussed in turn, and their impact on this research will be explained.

10.2.1 Shared Visions

The intention of this research method was to create a process whereby the speculative visions were created from the information provided by participants in the initial three data gathering sessions, to better facilitate discussions around the future of 3D printing technology, by presenting relatable, grounded near futures. It was hoped that these shared visions, or alternative social imaginaries, would provide a scaffolding, a framework if you will, that would allow each participant to construct and flesh out their own individual, imaginary worlds. This was achieved by loading each of the illustrated scenarios with small details that could act as entry points into these imaginaries. As has previously been described (Chapter Three), it was hoped that these visual hooks would act as trigger points to elicit comments from those who recognised them or would remain unnoticed for those who were not aware of their significance. Over the course of the research survey and the subsequent interviews, each of the visual hooks were used as anticipated, providing prompts and allowing the participants to discuss their hopes or concerns regarding the detail in question, or what they assumed its implications to be. These results suggest that this was a highly effective tool, and was even the topic of discussion with several interviewees, with one stating:

> It's a good way of judging what is more important to people in their responses, because across the whole image there are parts that draw my eye that won't draw other people's eye, and there will be bits I've missed that other people will have noticed immediately because of their personal interests. (Interview 2.04, 2019)

The use of multiple scenarios, each comprising a multitude of visual hooks resulted in a wide range of responses. Perhaps more importantly though, they also functioned as the intended entry points into the speculative worlds, leading to participants being able to project their own experiences onto the scenario. For example, upon noticing the large format printer and material hoppers in the future streetscape illustration [Fig. 5.8], two interviewees shared their first experience of 3D printing. The first recalled how contour crafting (large scale 3D printing of concrete (DeKestelier, 2013; Hager *et* *al.*, 2016)) was the first method of 3D printing she had come across, which would have been about 15 years ago when they were 14 and the second explained that they had seen a demonstration of this technology at a MakerFaire they attended approximately eight years ago.

Both of these interviewees expressed their excitement for the idea of seeing this type of technology outside of a research environment and “intertwined into everyday life” (Interview 2.01, 2019). An unexpected finding was also revealed, which is the extent to which these details revealed the unconscious bias and, in some instances, fears towards new technologies that the participants felt. One interviewee ended their monologue describing their fears for the future of autonomous robots by commenting, “maybe this is just my own personal biases towards robots that I'm just discovering I have” (Interview 2.03, 2019). As has already been explained in Chapter Seven, all of the details found across the three scenario illustrations were included as a result and in response to the three earlier data gathering sessions, and as such they all relate in some way to 3D printing, though this is not overtly obvious in some instances. This resulted in a high number of participants using this research survey to express their opinion on the future of multiple different technologies, primarily Artificial Intelligence, Drones and Robots, highlighting the point that visions of the future consist of evolutions of varied technologies simultaneously, which together fabricate a future understanding. Additionally, the implementation of complementary future-reasoned technology by the participants demonstrates the creation of their own entry points into their individual social imaginaries. Though interestingly, those who commented on the future of technologies typically did so to express their fear or concerns for a future where the technology prevailed, thus emphasising their objection of technology determinism. The opinions expressed by the participants, sharing their fears or reservations about the inclusion of certain technologies, were also found to be more detailed and critically engaging, often imagining beyond what was shown within the illustrations in question. In this way the use of speculative illustrations proved to be extremely successful in providing a platform for encouraging discourse and the building of alternative social imaginaries.

As the focus of these responses frequently veered away from the topic in question, they did evidence the success of this method for engaging participants in the discussion of speculative worlds, as people were able to relate to the illustrations and strong reactions were provoked. Of particular interest is the fact that these reactions were most typically fearful rather than hopeful, participants were far more forthcoming when pointing out and discussing elements within the illustrations that they felt negatively towards. This is due to the general bias of humans to give greater weight to negative entities (Rozin and Royzman, 2001), which makes this a highly effective method for revealing perceived challenges and barriers to a technology's successful adoption. In addition, there is also the argument that in the creation of social imaginaries, the inclusion of other considered future technologies creates a more well-rounded future vision, which was in part driven by engaging participants with questioning the future of one technology, in this instance 3D printing.

From the outset of this research (as outlined in Chapter Three), there has been a conscious effort to, wherever possible, greatly reduce or eliminate the potential bias of the designer responsible for the producing the future visions. Each element within the scenarios and the scenarios themselves were all carefully considered and informed by the findings of the three data gathering sessions, as a means of limiting the designers influence on the compositions (Dotson, 2015). The interviews provided the opportunity to discuss with the participants if they felt that the illustrations had provided a suitable backdrop for their thoughts, or that they had been overly influenced in some way. The majority of participants felt that the illustrations had been an effective approach, one commented that they felt it was a "very pure way of not leading anyone on with any bias" (Interview 2.04, 2019). Another commented on how they considered the chosen media of illustration as being an important decision, explaining how they understood this to mean that every detail included was specifically considered and intentional and was therefore something that means something "[t]here's nothing in there that's 'Oh well, that's just part of the image, that's not part of it" (Interview 2.10, 2019). The same interviewee also commented on the stillness of the images, as opposed to a film or moving image, which resulted in them being able to dwell on any detail of an image for as long as they felt necessary, stating “all these things are possible clues, and it's not this sort of shiny thing that I just sort of bounce off. I feel like I'm being welcomed into it and I can stay here, and it's like OK, have a think” (Interview 2.10, 2019).

Though on the other hand, others did recognise that they had been influenced by the illustrations, one participant explained that this was because they simply had not considered anything like this before, and so did not know what her thoughts were concerning the future of 3D printing technology. Another interviewee commented that they “found it difficult to imagine anything beyond what was proffered within the illustrations as future scenarios”, but did find it easy to imagine the scenarios as “they all seemed probable outcomes from the way 3D printing is going” (Interview 2.02, 2019) The same interviewee did however also go onto explain that they did not believe they would have been more successful at producing their own predictions, had they not been provided the illustrations as a starting platform. The majority of those interviewed however did think that the illustrations were necessary and appropriate, with one commenting:

> Even though I think a lot about 3D printing and thought about a lot of the implications of different strands of 3D printing. Seeing it in a different setting, even for me really brought things home. Especially with the 3D printer building for the other non-obvious advantages, those that aren’t related to the end-product or the cost, but they are related to the disturbance around technology. (Interview 2.01, 2019)

This was a good demonstration of how effective the use of visual hooks, situated within a mundane future setting, has proven to be. This approach allows a balance between the familiarity of the scenarios, and the disturbing effects of the emerging technology (Coulton *et al.*, 2019; Foster, 2013). Whilst this research has shown these illustrations to be effective, it is possible that they could also benefit from the inclusion of a supporting narrative, which could be achieved with the addition of a short story or written description that explores the activities being presented in the scenario, allowing the provision of further context. However, it should be acknowledged that this approach would also come with its own considerations for avoiding bias, for instance how a protagonist acts within a story could be leading. Therefore, whilst it is necessary to consider how much influence the provided illustrations (and potentially accompanying written narratives) will exert on participants, it is also important that there be suitable material in the first instance to elicit conversation and encourage a discourse, something which the illustrations have proven to be effective at.

10.2.2 Grounded Futures

At this stage in the discussion, it is important to comment on the efficacy of the chosen visual style for the graphic social futures. The medium of illustration was chosen as it has a long-standing relationship with science fiction and has been described as having a "resulting insistence on realism" (Mitchell, 1984). This is important as the manner that the image is presented has a direct relationship with "how it codifies information to draw in the viewer and enable him or her to connect to various visual cues within the image to make it legible"(Dunn and Cureton, 2020b). As explained in Chapter Three, the approach to composing each visual speculation was inspired by the future mundane, and resulted in the creation of lived-in futures, representing the idea that "[h]umans are covetous and sentimental, and we like to re-use and re-appropriate things, anything we create will inhabit the existing world" (Foster, 2015: at.15:25). This was a conscious decision, in an effort to provide an alternative to the polished chromium worlds that are often seen in "pop" future visions (Ackoff, 1993). This however, proved to be one of the most contentious aspects of this research method, with many comments directed at the way in which these futures were presented. The reason for adopting this approach is that when the visual hooks are inserted, they can be easily identified as something that is not yet a reality, as they sit in contrast to the lived in, and recognisable scenarios. It was considered that had the scenarios been presented as wholly fictional future landscape, there would be little opportunity to steer or guide the conversation to specific elements relating to 3D printing, because every detail within it could be considered as something that is not yet reality. The responses to the graphic social futures show that by using real world examples as the building blocks for the scenarios, a high degree of control can be achieved over where the audience is steered to focus.

Whilst participants were not necessarily aware of these efforts to ground the future scenarios in reality, the very fact that this was the approach taken was quite polarising. The main criticism of the future mundane approach was, put simply, that it was too mundane. This was echoed in the survey responses, having received numerous comments such as there's *nothing exciting/new here. Once upon a time people tinkered with cars, now they tinker with robots – boring!*, *seems bland and boring* and *The future looks a bit boring. Where are the hoverboards, flying cars and self-lacing trainers?* This reinforced the finding that there is seemingly a hunger for socially constructed imaginaries that are far more inspired by science fiction and fantasy, rather than what could be described as the grounded, grittier, and perhaps more real social imaginaries that this research presented. Whilst there is evidently a hunger for more ambitious and spectacular futures, this research considers grounded representations of *futures* as important for design research, as this allows us to better discuss the potentials for our everyday, lived-in *futures*.

The stylistic choices for the future scenarios, however, were not the only barrier to participants successfully engaging with the visions, as one of the participants explained:

> I think it's really difficult to feel inside a two-dimensional visualization, I'm a very visual person, but I felt that I would have felt more drawn into this scenario and have more emotional engagement with it, if alongside the visualization there had been some kind of narrative scenario, even a really small one, that would engage your participants in a way that would link them emotionally. (Interview 2.07, 2019)

This again was something that had been considered when planning for a public discussion, the intention was for each of the scenarios to be accompanied by a short narrative description to provide background information and help set the scene. With the move to an online survey however, it was considered that any extra 'pages' with blocks of text would either be skipped over, or be off putting for the participants, so this was an unfortunate, but necessary compromise. Considering the importance of an understandable narrative for engaging in futures (Morrison and Chisin, 2017b; Kirby, 2010b; Liveley *et al.*, 2021), the inclusion of a written narrative to accompany the illustrations could be beneficial addition to future research of this kind. An interesting alternative to this, which is afforded by the shift to an online platform, could be the inclusion of an audio narrative. These could be included alongside the visual scenarios, providing additional context without increasing the duration of the survey.

The results and comments received suggest that in some cases participants entirely failed to engage with the future scenarios. In several instances this issue arose when a participant was unwilling to accept the scenarios being presented as indicative of a future, being that it was not ambitious enough, or that they didn't recognise anything different to the present day. The responses from these participants focused very much on critiquing the illustrations and explaining why they disagreed with what was being presented. This was something discussed in the interviews, with one commenting "to me this is a real world, I can't see anything that is not possible. I think that's a pretty realistic scenario" (Interview 2.06, 2019). Interestingly however, in this instance the participant was explaining that this was the reason that they had successfully engaged with the scenarios. And whilst some participants were perhaps expecting a more sci-fi future, another interviewee commented that "there isn't that future where it's all spangly and shiny. It's not how it's going to be and it's not how it is" (Interview 2.11, 2019). Therefore, this would suggest that giving participants the agency to choose the timeframe that their scenario represents, ranging from the near future onwards (as is indicated in the backcasting diagram [Fig. 3.10]), could improve overall engagement. Much of the discussion relating to the future mundane approach focused on its aesthetic styling, whether as a positive or a negative, however there was one interview discussion that was far more encouraging. The interviewee expressed how the future mundane approach had:

> …opened up questions about otherwise, unfamiliar processes. I don't know a huge amount about 3D printing, but I do know about the experience of being on a High Street, I know about working from home, I know about being in a workshop... there's all this stuff there for me to be able to hold onto, I felt like, OK, this is giving me a way into imagining being in these spaces. And that was interesting for me. (Interview 2.10, 2019)

On reflection the lived in and mundane approach to *futures* can be considered a successful and appropriate stylistic approach to the creation of speculative future visions. Whilst there were indeed several participants who expressed their disappointment at them not being presented in a sci-fi fantasy style, they did nonetheless successfully provide a platform for discussions concerning futures. In fact, even those who were critical of this approach were still able to respond to the visions as intended as it provided a ‘way in’.

10.2.3 Asking the Right Questions

From the outset of this research, the primary vehicle for guiding members of the public in the consideration of futures was the illustrated speculative visions. As aforementioned, these were intended to be displayed and discussed in the public arena, the need for a specific set of accompanying questions had not been considered necessary at the beginning. Instead, it was anticipated that a guided discussion would be the most appropriate method for data gathering. However, the forced move of the research onto an online platform, necessitated the formulation of a series of questions to accompany the graphic social futures, to act as the surrogate guide throughout the process of completing the research survey. It was therefore necessary to discover how successful the participants felt the accompanying questions had been at guiding them through the process. One fact that stood out when studying the survey data was the length of time that participants had taken to complete the survey, which was on average, just under one and a half hours. This was far beyond the intended time for consideration of the survey, which was expected to be half an hour maximum when the survey was being designed (Lindemann, 2019). Considering the average time taken to complete the survey and the range and depth of responses that were received, this indicated that the questions performed better than had been intended, as participants were carefully considering their responses. Whilst the questions themselves where not a primary topic of conversation in the interviews, those who did mention them did so positively. One interviewee commented that "it definitely did need the questions because there's so much going on that you need to break it down and have specific focuses" (Interview 2.03, 2019). It was expressed by several participants that they did experience some difficulty in answering them, though this was a logistical issue rather than a criticism of the questions themselves. That is to say that several participants pointed out that by the second illustration, they realised that the questions alternated between a positive and a negative lens, and so they would be able to provide their range of thoughts on each illustration as they progressed through the questions, rather than trying to put all their thoughts regarding the presented scenario in one single comments box, something that many participants attempted for the earlier questions. As this was not made clear from the outset however, several participants explained that they had not divided their opinions correctly across the questions. It was also mentioned that this led some participants to become much more succinct as the survey progressed, primarily due to the realisation of how much time they were taking studying the pictures and how much of the survey remained incomplete, something they were able to gauge by using the progress bar at the bottom of each page.

For future research using this format it would be advisable to provide an outline of the survey format in the introduction. It had been considered for this survey, though without the benefit of hindsight it was thought that it would be off putting for people, which would result in the failure to attract participants to complete the survey. This was primarily due to the belief that the length of the survey would be a major factor in a participant's decision to take part. Having now seen the data concerning the length of time that people spent completing this survey, this proved to be far less of a factor than was anticipated and in fact the inclusion of this extra information could have aided participants in the completion of the survey.

10.2.4 Preferable for Whom?

Dunne and Raby point out that the idea of preferable is not a straightforward one, because it also raises the questions, “what does preferable mean, for whom, and who decides?” (2013: p.4). Visualisations afford designers the opportunity to explore alternative futures in ways that would be impractical or impossible in the real world, though this does not mean that these visualisations are without power or agency (Dunn and Cureton, 2020b). The relationship between futurity and design, specifically its role in *futures* is expanding, becoming a powerful means of visualising futures to be presented in an accessible and persuasive manner (Maze, 2019). These visions of the future can play a major role in shaping policy, cultural imaginaries, and market economies, suggesting this expanding intersect between design and futures is significant (ibid.). This research is concerned with the creation of alternative social imaginaries to explore the potential for social *futures* however, the politics of many future visions are not made explicit, yet the act of identifying and making a difference between what is real, now, and what is, or is not, preferable or negotiable in the future, is political (Maze, 2016). Buchanan positioned design as political rhetoric, arguing that:

> [R]hetoric is an art of shaping society, changing the course of individuals and communities, and setting patterns for new actions… designers have directly influenced the actions of individuals and communities, changed attitudes and values, and shaped society in surprisingly fundamental ways. (Buchanan, 1985: p.6)

Others have also argued that design is inevitably ideological and that by presenting particular future forms of social life and society, design exhibits inherent political dimensions (Maze, 2019). However, as Prado argued, “designers can be blind to normative positions, ideological biases and political consequences of their work” (quoted by Maze, 2019: p.28).

As a counter to this, this research developed the methodology for socially constructing, graphic social futures, putting the public in the role of providing the normative positioning, which acts as the framework that the scenarios are constructed around, essentially giving society agency. Though the visualisations are often considered to be the most valuable element of the project by the stakeholders, Gaziulusoy and Ryan (2017) explain that these are only the visual communications of the primary design artefacts, which are the scenarios themselves, in that visualisations are only capable of showing a single viewpoint of any given scenario. Gaziulusoy and Ryan go on to further explain that it is also not the scenarios themselves that are the ultimate goal in visioning exercises, rather it is the conversations that they provoke. These discussions, arising from the visual provocations, provide an understanding of the associated uncertainties, offer alternative perspectives, and a range of options to move forwards (Milestad *et al.*, 2014). As has already been discussed in Chapter Nine, the graphic social futures proved to be an effective platform for discussion, therefore the power is relinquished by the designer through the illustrations and handed over to those who can build their own social imaginaries using the illustrations as a provocation to either oppose or embrace what is presented.

As aforementioned, it has been established that future visions are used to visually describe alternative futures, some of which may be preferable (Dunn and Cureton, 2020b), however, this does raise the important question, preferable for who? This question was central to the development of this methodology, as the aim for social futures is to give voice to the everyday people who will inhabit these futures. It is for this reason that the public are positioned as stakeholders and actors in this process, informing the graphic social futures, which are then subject to further interrogation by the stakeholders. As was explained by Gaziulusoy and Ryan (2017), it is in these conversations that the true value of visioning lies. It was from the responses and conversations concerning the graphic social futures, that revealed what participants considered to be the ideals and aspirational norms of social futures. The futures presented by this research can therefore be considered those which are preferable to the participants, a collective representation, or *social futures*.

10.3 Limitations

This research is the combination of several methods and approaches, primarily borrowed from Futures Studies and Design Fiction. These have been selected to create a robust and considered methodology for the creation of socially constructed graphic social futures. This layered approach was arrived at as a means of reducing or removing the existing limitations of research within these fields, such as the creation of vapourworlds, as discussed in Chapter Two. However, there are of course some remaining limitations to this study, which will now be discussed. One major unanticipated obstacle to this research was the COVID-19 pandemic, however, as this was a global issue that could not have been foreseen, and the repercussions of this have already been discussed in Chapter Eight, this subject will not be discussed further. The limitations discussed here will be those concerned with the methodology itself, the means of data collection, time constraints and existing research in the field of social futures.

10.3.1 Methodological

The combined approach to the methodology of this research has revealed several limitations. Firstly, being that the graphic social futures are informed by the data gathered during the initial three data gathering sessions, the resultant future visions are therefore heavily dependent on the ability of the researcher to successfully interpret the findings of the data gathering sessions, using the critical lenses. This generative process is therefore made easier if the researcher is already familiar with and knowledgeable on the research subject. The results have also indicated that these future visions are extremely situated, a measure of their success was down to their specificity and relatability, so there can only be a limited geographical audience for each scenario that is presented, if they are to perform optimally. Not only are the resultant visions site specific, the ideas that are being shared are also representative of a specific set of demographics, and so an audience consisting of a similar demographic is the most appropriate audience for the final stage of the research process. An example of this would be the contrast between the responses received concerning the domestic workshop, for participants in North West England this was believable, for those participants located in South England, especially those in or around London, this was an extremely unlikely scenario due to spatial and economic restrictions, and to those participating from overseas, there was very little about the domestic scenario that resonated with them. This is the nature of research into the social imaginary, which itself is site specific, and therefore it would be appropriate for future research of this kind to target participants who were local to the scenarios being depicted, as opposed to the wide net that was cast by this research.

This research used the theories of STS to critically appraise and analyse the findings from data gathering sessions one, two and three (as described in Chapters Four, Five and Six), to qualify their meaning and interpretation. The intention was for this to limit the bias of the researcher in designing the scenarios, though ultimately this remained a qualitative study, and so was still subjective. Whilst this combined methods approach has proven successful, further work could be carried out to simplify and streamline this process, such as developing more efficient data gathering sessions.

10.3.2 Data Collection

The data gathering sessions were each designed for a specific type of wide data gathering, with the interpretation of the findings being used to inform the creation of the graphic social futures. However, what this research has shown is that the most valuable source of information proved to be the stories and impromptu conversations that occurred around this research (Gaziulusoy and Ryan, 2017a). Unfortunately, this information in several instances fell outside the designed data capturing process, and so the data gathering sessions were not able to fully capture this information other than anecdotally by the researcher, which is problematic and difficult to replicate. Thankfully as the researcher was present throughout each of the data gathering sessions, this information was ultimately able to be made use of. Future research using this approach would benefit from a more flexible and combined approach to data collection. Though it should be noted that whilst this anecdotal information proved to be extremely rich, the additional layer of analysis and consideration that was required to use this, did further complicate and lengthen what was already a difficult process, as has been discussed in Chapter Four, Five and Six. This was primarily caused by having multiple sets of data that were in formats that were not compatible, or easily comparable. Therefore, any additional means of data gathering, such as recorded discussions or participatory design workshops, would be required to have a well-considered and perhaps more streamlined process for analysing the collected data, which would likely include more discursive findings.

10.3.3 Time

The final limitation of this research is the duration of time that each stage of the process takes, being that this approach is comprised of multiple stages, that are intended to be carried out sequentially so that the findings from one data gathering session can inform and shape the design of the next. This results in an extremely time-consuming process, being that subsequent data gathering sessions can only take place once the responses from the previous have been fully analysed and interpreted. This iterative and multi-layered approach to the creation and testing of these graphic social futures was created as a means to ensure there was a rigorous process for their creation, which would reduce unconscious bias and be replicable by other researchers looking to use this method. Though other methods, such as participatory design is also capable of mitigating this issue, by giving greater agency to the participants. Although participatory design has proven to be an effective method for engaging the public in conversations around futures (Gaziulusoy and Ryan, 2017b; Pollastri, 2017; DiSalvo *et al.*, 2012), this research considered it to be more important to engage with a higher number of people than would be practical with participatory design, considering that these graphic social futures are the result of the thoughts and ideas shared by 236 participants. The use of participatory design however could potentially allow for a more inclusive process and so is worth consideration for future projects using this method.

It is also likely that future research using this method could reduce or amend aspects of this process to speed up this process. This is most certainly the case if this was to be carried out by researchers with more experience and knowledge in data gathering and analysis, or perhaps even more appropriately, a team of researchers with specialisms in each of the appropriate research methods being used. Another alternative approach to this method could be to run the data gathering sessions in parallel, though this would forego the ability to amend the design of subsequent data gathering sessions, based on the findings.

Regardless of these limitations, this approach to the creation of graphic social futures, using visual hooks informed by participant responses, has proven to be successful in its aim of guiding the public through the consideration of, and the discussions around *futures thinking*, with key insights and findings revealed as discussed in this chapter.

10.3.4 An Opportunity in Disguise

The final limitation to discuss is the limited quantity of existing research that has been carried out in the field of *social futures*. Whilst the field of *futures studies* is well established, the specific field of *social futures* is still emerging and is not yet well defined, which in part this research attempts to do. Of the relevant research that does exist within this field, very little of it is concerned with the creation of visual futures and is instead a literary exercise. There are several reasons for this, primarily these are, the complexity of producing visual representations of a futures vision, and the duration of time that the process of both visioning and visualising takes. It is for this reason that this research has necessitated a combined methods approach, borrowing from other established fields of study to create an appropriate process to achieve the research aims. Whilst this did permit the consideration of methods and approaches that might otherwise not have been considered, the lack of research material in this area of social futures studies does point to the need for further research.

Whilst this is a limitation of this research, this has also provided the opportunity for this research to contribute significantly to the methods through which social futures can be studied. This research has provided a means of engaging the public in futures research, giving them a voice and the agency to prototype their own alternative imaginaries. It has also demonstrated where within the wider field of *futures* studies these graphic social futures sit, as discussed earlier in this chapter, p.303 and depicted in figure 2.10, p.79.

10.4 Recommendations

10.4.1 Data Gathering

This research found that the public are very willing to contribute towards futures research if asked to share their thoughts. Retrospectively however, the way in which this research collected the information could be significantly improved. It was considered that the most efficient means of analysing the data would be to devise a series of questions which would provide answers that could be collected and coded, using the data analysis software Tableau, and then the results critically appraised by the researcher using the critical lenses (as outlined in Chapter Three). However, as has been previously mentioned, one of the limitations of this approach was the inability to record the richness of the stories and conversations that were shared by the participants, following or during the process of completing the data gathering session research activity. These stories and conversations provided a much fuller understanding of their responses and provided context and a depth of consideration that was not always possible to record using the data collection methods as designed, which is often the case when doing research in the wild (Rogers and Marshall, 2017).

Therefore, this research would recommend that any future work using this method, should ensure that there is sufficient focus placed on capturing the information shared by participants during the conversations and discussions that accompany the data gathering sessions. As has been pointed out by Liveley (2021: p.226):

> In the context of social futures, therefore, narrative is not only a 'social product' but also a 'social process or performance in action' and a social 'structure of knowledge' – at once 'text, shared discourse and emergent cognitive and communicative process'.

This certainly proved to be the case for this research, with some of the most valuable and insightful findings, being the result of the discussions concerning the graphic social futures and the research process itself. It was through stories and narrative that participants were able to convey their thoughts and ideas most successfully around *futures*. Therefore, certainly for this research, it was the quality of the data being collected that was the most important aspect, far less so than the quantity. It is in the stories and conversations that the graphic social futures provoked, that the participants ideals for social futures are revealed.

10.4.2 Appropriate Representation

A further recommendation would be to recognise the importance of representation when producing the graphic social futures, as noted previously in Chapter Nine. And to consider that every detail, regardless of how insignificant it may be considered by the researcher, could be perceived to be of importance by a participant. Both of these facts became extremely clear during the final data gathering session, and despite having considered both of these factors (which were also discussed by *Strange Telemetry* in their *Ageing population report* (Voss *et al.*, 2015a)), the efforts that this research made to address these issues were not sufficient. Despite the illustrations being designed with the intention of focusing the discussion on the social futures of 3D printing, this issue of representation affected the participants ability to engage with the scenarios to such an extent, that for those who did not feel they had been appropriately represented, it was extremely difficult for them to see past this issue. Therefore, if the participant is unable to 'see themselves' within the scenario, they found the process of considering these futures to be extremely difficult, and in some instances impossible. This issue was discussed in Chapter Nine, where it was pointed out that careful balance within the scenarios is required to ensure that there is an appropriate level of representation, whilst not shying away from existing inequalities that would be excluded by presenting a misleading and overly optimistic image of reality. However, it is suggested that further studies in the area of graphic futures could be conducted by teams of researchers that comprise a range of views in order to achieve true diversity and representation.

10.4.3 Improved Agency

Agency plays an important role in the way that people engage with futures (Ahvenharju *et al.*, 2018). There are three ways in which this research could improve the degree of agency that participants experience in this process. One of the criticisms levelled at the speculative illustrations is that they did not live up to more optimistic, spectacular future that the participants had expected to see. In part it is considered that this is due to the chosen approach of presenting a mundane, lived-in future. However, another contributing factor to this is likely to be the timeframe chosen for these speculative scenarios, in that they represent a near future, therefore they are intended to be not too dissimilar from the reality of today, which was done intentionally to make them accessible for the audience (Foster, 2013; Coulton *et al.*, 2019). A solution to this issue could be to produce dynamic graphic social futures that are composites of different elements that change over time, e.g., in increments of 5 to 10 years. This could be used to reveal the timeframes in the future that participants are most comfortable with, what futures they accept as credible and at what point in time these speculations cross over into sci-fi fantasy. The method that this research has produced is already capable of doing this, being that the backcasting method can just as effectively be used to produce multiple scenarios along a given timeline, though this would be beyond the scope of this research and would be more directed at future work in this area.

Another way that participants could better engage with the graphic social futures would be to produce speculative scenarios which have a degree of interaction. This could take the form, for example, of a graphic novel style choose your own adventure, whereby the reader assumes the role of the protagonist and makes choices that determine the main actions and plot outcomes. This would also benefit from the opportunity to add a written narrative to accompany the visualisations, which would be greatly beneficial (Raven and Elahi, 2015; Morrison and Chisin, 2017a; Liveley *et al.*, 2021) and potentially avoid the bias of the designer thus enabling participants to choose, and dynamically and adaptively construct their own social futures. It is anticipated that both of these changes to the process would result in the participants feeling they had more agency and therefore a greater level of investment, in the futures being depicted. However, as has been discussed in Chapter 3, the design fiction as world building approach intentionally avoids providing people with a specific message about the world that has been created, rather, it shows different views of the world to allow the viewer to decide their own opinion about the future based on their perspective. Therefore, it would need to be carefully considered how these two approaches could be combined for further studies in graphic futures.

The third and final improvement to participant agency is the introduction of participatory or co-design into the process. These have already proven to be successful methods for engaging people in futures research (Oliver, 2019; Knutz *et al.*, 2016; Sanders and Stappers, 2008; Ahmadpour *et al.*, 2019), however, these methods were not used in this instance as it was considered not suitable for the high number of participants that this research was hoping to engage. It could be conceived however that groups or teams of participants could be lead through a co-design workshop, providing a greater depth of feedback than was possible through the data gathering sessions. This would perhaps not provide the range of responses but would likely be a more effective means of removing the designers bias from the process.

10.5 Summary

This chapter has outlined the three major elements that are responsible for the success of this method for producing graphic social futures. These are the use of shared visions, to provide a platform for discussion, the style of these visions, being that they present a grounded and lived in future, and finally the accompanying questions, which encourage the audience to consider the scenarios from different viewpoints. This was followed by an explanation of how this research has addressed the issue of who *preferable futures* are for, and utility of grounded and accessible future visions. Having discussed the successes of this research, the limitations have then been discussed, followed by several recommendations for how these limitations could be mitigated, and this research improved upon. The following chapter will provide the conclusion to this research, providing a brief reflection on this work, the contributions of this research, and suggestions for future research in this area.

11.0 Conclusion

11.1 Introduction

This chapter begins with an explanation of how this research has answered the research question, followed by reflections on the research itself. The main contributions of this research are then discussed, and the chapter is concluded with recommendations for future research.

11.2 The Research Question

Design Fiction is an established method that allows researchers to construct arguments about feared or dystopian futures and articulate the possible consequences of these to a broader public (Dunne *et al.*, 2016; Dunne and Raby, 2013). The aim of this research was to develop a methodology for using a design fiction as world building approach to produce speculative visons, which were socially constructed, with the intention of revealing otherwise unnoticed challenges, barriers, and limitations of emerging technology. This research has shown that graphic social futures are an effective tool for engaging members of the public in futures research. Not only did this methodology reveal valuable insights concerning how people engage with futures research, but it also uncovered several present-day issues and concerns, such as underrepresentation or A.I. technology, which while disparate elements, are all part and parcel when considering *futures* as a holistic whole.

During each of the data gathering sessions, members of the public were enthusiastic to participate, which resulted in the collection of substantial data sets, subsequently leading to important and interesting insights. The data gathering sessions therefore proved to be an effective method for public engagement and data gathering. Moreover, once the graphic social futures were introduced, the findings from this research were even more in depth, and participants proved to be far more likely to elucidate on their reasoning behind their responses, and also to discuss their wider ideas and concerns. The provision of these alternative imaginaries as a platform for them to explore their own futures, revealed a noticeably improvement to both the quality and quantity of insights. Therefore, whilst this methodological process is complex and time consuming, the iterative nature of the data gathering sessions has proven to be an effective, and this research would argue necessary, step. This is especially true considering the proven criticality of every detail that is included or excluded from these speculative scenarios, and the importance of being able to trace these decisions back to the findings.

11.3 Reflections

This methodological approach to *futures* research was designed to use design fiction as world building, in a manner that not only involves the public in this process, but makes them an essential component, thus giving a voice to the public who are ultimately the stakeholders in these *futures*. Though, as has already been discussed in Chapter Ten, it is possible that greater agency could be given to the public in this process, with the introduction of participatory design for example (Baumann *et al.*, 2018). Regardless, the resulting graphic social futures were then be presented to the public as a platform for discussion. The expectation was that these graphic social futures would enable the public to successfully engage with futures research, and that this would not only give the participants a voice but would also uncover findings that would otherwise remain unnoticed, such as the widespread concerns for the future of A.I. Technology. The fact that this insight (along with the many others as discussed in Chapter Nine) into the public's fears and concerns for the future was beyond the expected focus of this research proves it to be more effective than had been anticipated, as it elicited considerations beyond the focus of 3D printing. Though, one could argue that once one element of the future is considered it is a carrier for other considerations of the future.

This was of course not a perfect process, one of the first issues with the graphic social futures to be revealed was the setting of the scenarios themselves. Though each of the scenario represented existing scenes, these were oftentimes deemed to be perpetuating a stereotype that participants expected would no longer exist in the near future. A good example of this would be the Near Future Makerspace scenario, which was criticised for its uneven representation of gender, however, this scenario was very much based on, and representative of the current demographic of users in these spaces. This revealed that the participants considered this to be an issue that needed resolving, which is something that is actionable now. The graphic social futures could therefore be a valuable tool for exposing possible flawed futures, and provoking debate on how things could, or should be, and consider how we get there, with stakeholders in the present.

Whilst the contextual driver for this research was the social *futures* of 3D printing technology, the socially constructed graphic social futures proved to be highly effective at not only highlighting peoples expected use cases for this technology, but also revealing the challenges and barriers that are currently, or in the future could potentially prevent the successful adoption of this technology. This was facilitated by the inclusion of the visual hooks, which proved to be extremely successful as entry points into these alternative imaginaries. This was evidenced by how effectively the participants constructed fully fleshed out worlds and narratives in the discussions, which was further evidenced by the fact that some participants also revealed their apprehension or concerns for technologies that could be considered only tangentially related to the elements within the illustrations, such as fears for self-driving cars or sentient A.I. technology. These were all concerns born from their own alternative imaginaries, but were constructed around, and made possible by the scenarios which had been presented.

This suggests that further work could use this methodology for creating socially constructed imaginaries to create richer graphic social futures that explore some of the wicked problems that society faces, such as poverty, climate change, sustainability etc. Comparative lenses, appropriate to the research topic, could also be provided, through which specific themes or challenges could be examined then analysed in relation to one another.

11.4 Contributions

Being that this research has taken a mixed methods approach and has been inspired and informed by several different fields of study, this research has also resulted in a number of contributions, which will be discussed in the following sections.

11.4.1 Visual Tools

Futures visioning is already well-established process for promoting the core values and beliefs of a corporate entity (Rose, 2017), yet there is currently no equivalent process for promoting the values and beliefs of society (Slaughter, 2020). The social imaginary is informed and carried in images, stories and legends (Taylor, 2004), which is why it is necessary to have methods for the creation of social imaginaries that are free from commercial interest and instead are driven by the social. This research has developed a methodology for the creation of graphic social futures in an effort to address this.

Throughout every stage of this process, it has been shown that the public are enthusiastic to participate and share their thoughts on the subject of futures*,* if given the opportunity. Each of the three initial data gathering sessions, prior to the creation of the graphic social futures*,* provided a foundational understanding of the expected and anticipated uses for 3D printing in the future, though it was difficult for these data gathering sessions to discuss anything beyond what participants expected to use this technology for. During discussions that took place around these data gathering sessions however, it became clear that whilst people expected to use 3D printing technology, they had not really considered why or how. Though it certainly tapped into people aspirations, and in the majority of instances was considered a means of owning something that was otherwise unobtainable, such as a supercar or autonomous robot. Once the graphic social futures were introduced however, the conversation drastically altered. The focus quickly shifted from discussions concerning the objects and artefacts that they would produce, to instead discussing their fears and concerns for the future and hopes concerning wicked problems that we may yet successfully tackle. The use of visual representations of *futures* encouraged social, rather than individualistic considerations. This is perhaps to be expected to some degree, considering that the scenarios presented were for the most part social settings that they were being placed within, though the questions that the participants were asked to consider, were consistently personal. Despite this, participants responding to the graphic social futures were much more inclined to comment on how they anticipated these futures affecting others, be it positively or negatively.

It is important to acknowledge that the questions posed to the initial data gathering sessions were very much focused on the technology in question. However, it was only possible to open the questions to possibilities beyond 3D printing technology itself, as was the case with the research survey, once the illustrated scenarios had been created. In a sense, the data gathering sessions were collecting the parts required to collage/build a convincing world, including all the necessary details to describe the present, through to the possible manifestations of *futures* with 3D printing. Whilst participants in the research survey were informed that this research was concerned with 3D printing, many of their responses frequently wondered to other matters, even if they had begun by discussing the subject in question. This suggests a comfort and ease when engaging with these visual scenarios when compared to the earlier data gathering sessions. In this way the visualisations proved to be successful in allowing and encouraging the public to explore social futures. This not only improved the level of engagement from the public in *futures* thinking, but also highlighted the importance of world building, to provide the context necessary for them to consider *futures*, resulting in the stories that were shared showing much more depth.

The illustrations provided a steppingstone for the participants to begin thinking about futures, by offering something for them to react against, or to. This was something that did not happen when simply talking to the public, because of the difficulties of thinking about futures (Gaziulusoy and Ryan, 2017b). These graphic social futures were perhaps less about allowing people to think about possible solutions to problems, but instead were much more useful at highlighting some of the current challenges. This then permits further discourse about things that might need to be changed in the present, by exposing possible flawed futures and provoking debate on them now with stakeholders, which is why an approach using design fiction was chosen because it is often utilised in this regard.

11.4.2 Social Futures

This research contributes to the emergent field of *Social Futures* research, by helping to further define this field with the development of social future visions. This provides a practical visual narrative approach, which this research has shown to be an approachable method for public engagement, as an alternative to the more established theoretical and literary research that is already being carried out in this area. There are examples of social futures research that has made use of cartoonists to produce roadmaps and similar (Lackovic *et al.*, 2018), but most research in this field shies away from producing visual speculations of *futures.* This is for several reasons e.g., it is extremely difficult and time consuming, as has already been discussed in this thesis. The challenge is in striking an appropriate balance with a great many factors, such as ensuring there is sufficient representation and sufficient details to act as entry points to the world, but not fully rendered so that the viewer can fill in their own details and more easily build their own imaginary etc. The methodology that has been presented by this thesis, which uses data gathering sessions to engage with the public for the creation of socially constructed speculative visions, provides a means to navigate this difficult path (as shown in figure 11.1), to create future visions that are open ended, provisional frameworks, that afford the public opportunities to aid in their construction. Considering the widespread potential impacts that 3D printing is reported to have, this research took the view that it was therefore important to engage with a wide sample of the public, though this large number of participants made the prospect of using co-design or participatory design problematic. Research using smaller focus groups, could benefit from including the participants in the designing of the graphic social futures themselves, by guiding them through the creation of their own individual visions, and could potentially be the focus of future research relating to social futures.

This research has also begun to develop a visual explanation of how different approaches to futures visioning aligns with the different levels of depth in futures thinking (discussed in Chapter Two and Nine). Social futures as a field of research acts a container, allowing consideration for each of the "depths" in futures thinking; "pop" futurism, problem-oriented futures work, critical futures studies

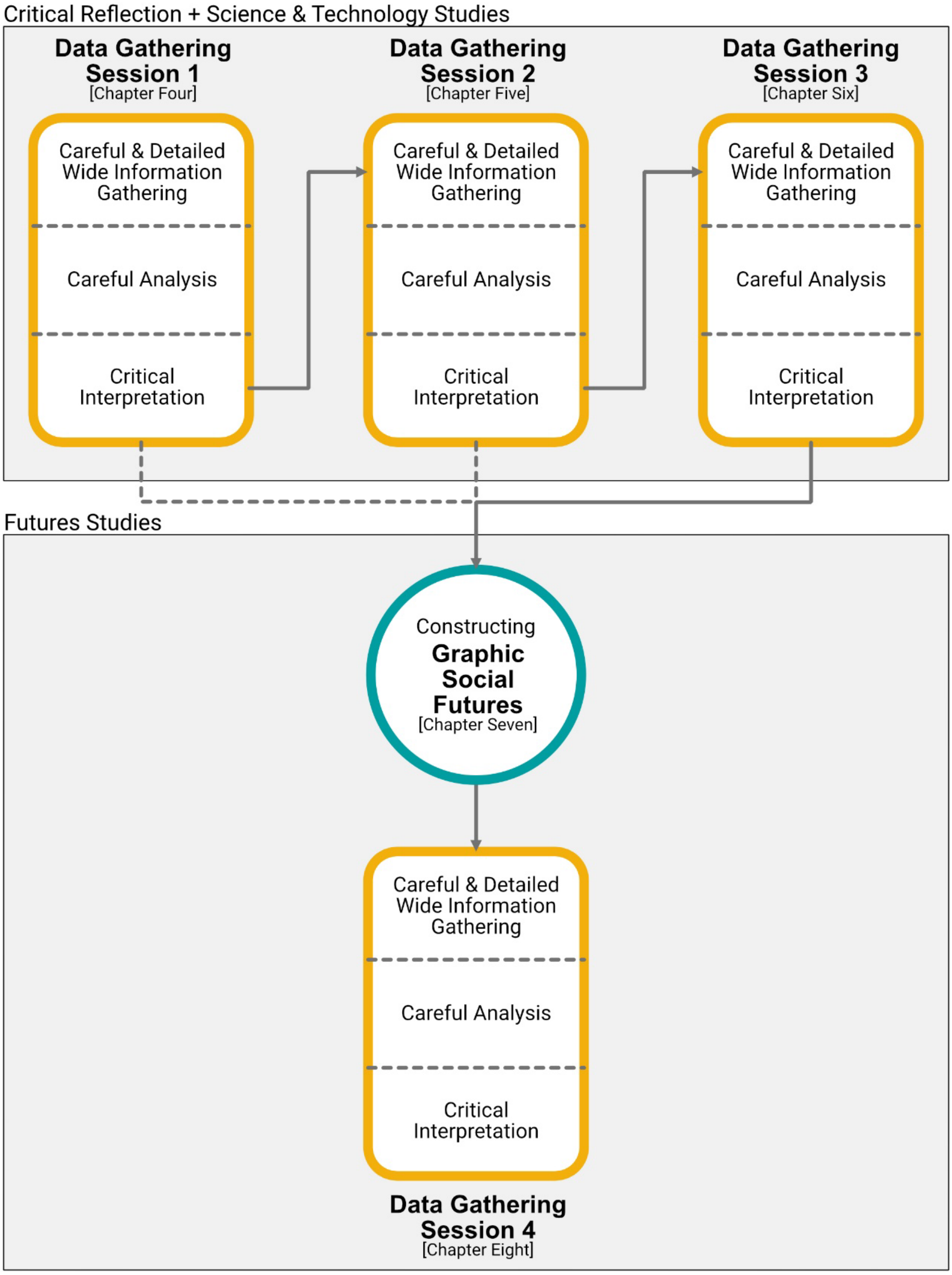


Figure 11.1 Methodological Diagram – This diagram explains the process that this research has developed for the production of graphic social futures, indicating the relationship between the data gathering sessions, critical lenses and how these are used to inform the socially constructed illustrations.

and epistemological futures work. This research, however, as has been outlined in Chapter Two, sits within the critical *futures* studies level. Over thirty years ago, Slaughter stated that “there is still far too little futures work carried out explicitly for the public interest” (Slaughter, 1989: p.461), more recently, when discussing critical future studies, Goode and Godhe described it as “a timely and even urgent project at our current historical juncture” (2017: p.1). This research has contributed to furthering this emerging field of futures study by developing a research tool for those working in the critical futures stratum of futures studies. The methodology for generating graphic social futures engages with the public, who are ultimately the stakeholders in these futures, and provides a platform for imagining, investigating and debating different potential futures.

11.4.3 Design Fiction ‘in the wild’

This research tackles one of the primary criticisms of design fiction, its failure to live up to the promise of “helping people participate more actively”, because it’s “capacity for sustained public engagement… has thus far been under-explored” (Voss et al., 2015b: p.3). Dunne and Raby (2013: p.154). suggested that “[t]hese days, exhibitions are highly accessible… museums can become laboratories for rethinking society, places for showing not what already exists, but more important, what is yet to exist” However, as research has shown, exhibitions are not easily accessible to everybody (Tlili, 2008; Sandell and Nightingale, 2012), which is problematic for a method that promotes its ability to engage with the public.

This research contributes to the work that has been carried out by *Strange Telemetry*, *Near Future Laboratory*, and Coulton etc., in efforts to take design fiction out of exhibition spaces and into the public domain. This research successfully engaged with the public at multiple stages throughout the process, resulting in design fictions that were developed using a bottom-up approach. Produced in this way, the public are given agency within the process, rather than merely being an audience for the end product. This not only encouraged engagement with the research, but also intentionally tackled the criticism that “[m]any speculative design projects either operate as stand-alone spectacle, or as engagements with those deemed to have ‘expertise’ – scientist and technologists, political scientists, economists, but rarely wider publics” (Voss et al., 2015b: p.3).

11.4.4 Futures Visioning

This research also contributes to the understanding of how *futures* are visioned. It has demonstrated where within the field of futures studies these graphic social futures are situated, using Slaughters (Slaughter, 1989, 1999) depth in futures thinking to provide the existing context. This was combined with Montgomery’s Unresolved Mapping of Speculative Design (Montgomery, 2018), and the idea of resolution was introduced by this research, as a means of differentiating between visualisations that are representative of fully resolved worlds, such as “pop” futures – such as Minority Report (Spielberg, 2002), and those which are acontextual and vague, such as corporate visioning (Microsoft, 2015). Graphic social futures, as described by figure 2.10, (p.79), in terms of the resolution of world building, occupy the space between, being that they are intentionally contextualised, but not so fully resolved that they lack flexibility or porosity, which is necessary for the viewer to contribute their own thoughts and ideas. Parallels were also drawn between the process for understanding *futures* as put forward by this research, and Levitas’ Utopia as Method (2013a), which can also be understood in line with the work of Slaughter (1989), and Mochelle (1986), as discussed in Chapter Three.

As Gasiulusoy and Ryan (2017) explained, the visualisations are just one small part of the scenarios, and it is the conversations and discourse that the scenarios elicit is the goal. Unlike existing projects which have used futures visioning to engage the public and build awareness, capacity, and agency concerning wicked problems, such as climate change (Sheppard *et al.*, 2011; Gaziulusoy and Ryan, 2017a), this research has developed the process further process whereby it is the publics responses to the visualisations that reveal what they consider to be social futures and of importance. It is not simply a top-down approach, where the aim is to directly influence the attitudes and values or change the actions of individuals and communities (Buchanan, 1985), but is instead a bottom-up approach, that seeks to reveal the attitudes and values of individuals and communities.

11.5 Future Research

Over the course of the last two chapters there have been several suggestions already made for future research, what will be discussed here however, are the two primary suggestions for future research that emerged from this thesis. The first is an improvement to the method for creating the graphic social futures, as discussed in the limitations section of Chapter Ten, the second is a refocusing of this method to explore the wicked problems that society faces.

11.5.1 Addressing the Limitations of Time and Data

The first suggestion for future research would address two of the limitations of this research that have already been acknowledged, which are data collection and time. The methodology that has been developed through this research is reliant on the three initial data gathering sessions, which are intended to provide an understanding of the underlying social structure. Whilst this proved to be effective, the type of data that was collected as part of these wide information gathering sessions, could be improved upon. It was revealed whilst carrying out the task of creating the graphic social futures, that the most useful data was provided by the conversations and discussions that had occurred alongside the data collection, because the stories that were shared had much more richness and depth. Therefore, it would be suggested that rather than carrying out data gathering sessions with an aim to collect large data sets, the focus could instead be placed on a smaller number of more detailed guided discussions with individuals or small groups. As has already been suggested, this could also provide the opportunity to engage the participants in co-designing the graphic social futures themselves. It had been anticipated that having data sets that could be coded and analysed, would be sufficient to inform the curation of the graphic social futures. In practice however, it was equally challenging and time consuming to interpret the data that was collected, regardless of its form.

Recorded guided discussions also have the benefit of the researcher being an active participant in the process, rather than a bystander. The process of understanding and interpreting the results begins at the same time as the data gathering, therefore this should greatly reduce the time taken to carry out the initial data gathering sessions. It is worth noting that there would still be the need to use a series of appropriate critical lenses to inform the interpretation of these findings, but this should still make for a more streamlined process.

11.5.2 Exploring Wicked Problems

The second suggestion for future research would be to take the methodological approach for the creation of graphic social futures, that this research has developed, and focus it on the exploration of wicked problems. An unexpected result of this research has been the discovery that by pushing back against the portrayal of fully realised utopias and presenting a future which is still very much a work in progress, the speculative visions were highly effective at eliciting reactions from the participants. Their reactions revealed what changes the participants had been expecting to see in a future scenario, which in turn revealed the problems of today that they are concerned about. The inclusion of visual hooks to hint at and signpost participants towards certain ideas was an especially effective technique, resulting in many discussions which were only tangentially relevant to the original question that had been asked. Though it should be acknowledged that without appropriate consideration, the inclusion or exclusion of certain details could also be used to manipulate people. Presenting visualisations that could be used in support of climate change denial or any number of conspiracy theories (Hannah, 2021), which is another reason that this is an important issue to be aware of. The findings of data gathering session four, as discussed in Chapter Nine, also made clear the importance of considering and trying to understand the different cultural contexts that the research will engage with.

Whilst the use of visualisations makes the research more universally understandable from an engagement standpoint, the use of visualisations also presents problems surrounding the different cultural connotations and readings of the details that are depicted (Ranasinghe *et al.*, 2018). This highlighted the importance of considering as many details, at as many scales, as possible when composing the graphic social futures. The decision to use illustration as the preferred medium proved to be effective, allowing for a high level of control over where and which details are included. This same level of control is of course also available using other mediums, such as computer-generated graphics, though often the representation of people in this manner opens itself to the uncanny valley effect (Wang *et al.*, 2015b), which is not compatible with an audience's suspension of disbelief (Encinas *et al.*, 2017). It is therefore suggested that future work could use this methodology for creating socially constructed imaginaries to create richer graphic social futures that explore some of the wicked problems that society faces, such as poverty, climate change, sustainability etc. Multiple problems could be addressed using this approach, and comparative lenses could be created to examine specific themes or challenges. These could then be compared in relation to one another, exposing challenges and problems, to provoke meaningful discussions about how we can make positive change.

11.6 Summary

The methodology put forward by this research, for the social construction of graphic social futures, has been shown to be an effective tool for engaging the public in futures research. It is suggested that future research using this approach could benefit from the inclusion of participatory design, at the data gathering session stage. By doing so, this would not only increase the agency of the participants within the process, but would also reduce the number of stages necessary, prior to the creation of visualisations.

In this instance, the methodology developed by this research, was focused on the exploration of alternative pathways in relation to 3D printing. It is suggested however, that in addition to being effective at exploring possible futures, using emerging technology as a driver for change, this method could also be an effective means of exploring the wicked problems that society faces today.

12.0 References

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