

## **Shaping Things': Design Fiction as a catalyst for design in design and technology**

Drawing directly upon earlier work and informed by the findings of more recent studies, inspired originally by the work of Bruce Sterling, this paper presents a collection of narratives from experienced design and technology teachers who were introduced to the notion of 'design fiction' during their teacher education programmes to use as a catalyst to effect innovative pedagogical approaches to the teaching of design and technology.

Specifically, this paper seeks to explore the advantages of using this notion as a tool to focus not only on the effectual delivery of design, but in order to support the creation of a high-quality conceptual outcomes, where learning is concerned with innovation and the development of skill, rather than to produce a fully functional working model or artefact.

Having brought to the fore exemplar work created by the pre-service teachers themselves, presented in the form of vignettes, participants (who are now experienced teachers) give first-hand accounts of the influence that using design fiction as a catalyst for teaching has had on their own classroom practice. Adopting a case study approach, work presents examples of best practice, in practice, and explores specifically the advantages (and disadvantages) of this approach.

Participants report how this approach has supported the consolidation of learning, reinforcing skills, knowledge and understanding. Findings also make clear that through the adoption of design fiction teachers witnessed an increase in student motivation to engage in design activity, and notably when working within traditionally gender dominated areas of the design and technology and STEM curricula, gender bias decreased. In summary the work concludes with an overview of useful links as an aid to support those considering the exploration of this approach in their own settings, and in order to build upon work undertaken advocates the need for staff development to ensure developments within the field of speculative design are capitalised upon by teachers of design and technology education.

### **Introduction**

Inspired originally by the work of Bruce Sterling, this paper presents a collection of narratives from experienced design and technology teachers who were introduced to the notion of 'design fiction' while following their Undergraduate Design and Technology Initial Teacher Education (ITE) programme, which was undertaken within a Higher Education institution in England between 2008 and 2012.

Drawing directly upon earlier work by Bell and Wooff (2012), Bell and Jones (2013), and informed by the findings of more recent studies (Hardy, 2018; McLain *et al.*, 2017) in presenting the participants' perceptions of the concepts use within design and technology education, this paper seeks to illuminate the impact that using design fiction as a tool to focus not only on the effectual delivery of design has had, but as a vehicle to support the creation of a high-quality conceptual outcomes, where learning is concerned with innovation and the development of skill, rather than to produce a fully functional working model or artefact.

The paper begins with a brief outline of the original work, followed by a definition of design fiction as perceived within the context of this paper and moves to examine the literature, before presenting an outline of the participants' own degree work, where they were encouraged to embrace the notion of design fiction within design and technology; to use as a catalyst to effect innovative pedagogical approaches in their teaching, particularly their approaches to the delivery of design capability, innovation within the context of product design.

Having brought to the fore exemplar work created by the participants (created when they were themselves pre-service teachers), presented in the form of vignettes, participants (who are

now experienced teachers) give first-hand accounts of the influence that using design fiction as a catalyst for teaching has had on their own classroom practice. Hence adopting a case study approach, work presents examples of best practice, in practice, and explores specifically the advantages (and disadvantages) of this approach, leading to the formulation of the research question:

*What impact has the introduction of 'design fiction' had upon the classroom practice of design and technology teachers?*

Finally, the paper explores developments in the field and concludes with future next steps, specifically suggestions for teacher education and continued professional development within the context of design and technology education.

## **Background**

This study draws upon work undertaken with pre-service teacher between 2008-2012 who were studying for their Undergraduate degree in design and technology education. During the University based element of their training, the pre-service teachers were introduced to the then nascent notion of 'design fiction'.

Positioned predominantly within the context of future design within science-fiction films, pre-service teachers were encouraged to challenge their thinking around the use of the established term 'science fiction' and embrace the concept of design fiction (de Vries, 2007).

At the time, a situation which sadly a decade on remains the same, as a subject design and technology was under threat (Barlex, 2017; Irving-Bell *et al.*, 2019). Physical resources were scarce, as was curriculum time and pre-service (as well as in-service) teachers often expressed the challenges of engaging children in meaningful design activity, when all the children wanted to do was to make and a 'take-home' product was what was expected.

In response, to support their development as classroom practitioners, and in doing so combat the challenges faced in school, work undertaken also sought to move pre-service teachers away from their own pre-conceived ideas about teaching design, where supported by curriculum guidance at the time (DfES, 2004) the teaching of design had become formulaic and was often delivered as a history lesson. Furthermore, the subject content for new general certificate of secondary education (GCSE) design and technology encourages students to take more designedly approaches, including "considering contemporary and potential future scenarios from different perspective" (DfE, 2015). However, entries for the qualification are in decline, dropping 24% in the period from 2017 to 2018 (Cultural Learning Alliance, 2018). This is indicative of the continuing challenges that creative and practical subjects are experiencing, with only art and design entries remaining stable in this period.

As such, approaches to session delivery were informed by the work of Trigwell (2002) and pivotal in that they actively sought to support the pre-service teachers to challenge their own conceptions of the subject, and within a framework of support to push themselves out of their comfort zones and to move beyond their own pre-conceived ideas of how design could or should be taught.

In addition to the media of film (including *Back to the Future*, *Total Recall* and *The 6<sup>th</sup> Day*) to support delivery pre-service teachers were encouraged to read around the literature. Coupled with the introduction of concepts including *Cradle to Cradle* (2002) and *The Circular Economy* (Ellen Macarthur Foundation, 2011) and early iterations of design fiction as a tool to support the teaching of design (Stables, 1992), design fiction was introduced as a catalyst to stimulate innovative design for themselves, as well as to use with the children they were training to teach.

## **Literature review**

Before moving to examine the literature within the field it would be useful to present, within the context of this paper the definition of design fiction used “is a bit new and weird ... and portrays a different kind of future than you might have been used to” (TBD Catalog, 2019, p.1).

Since the term was coined in 2005 (Sterling, 2005) the notion of ‘design fiction’ has been applied to and developed within numerous contexts including Artificial Intelligence (AI), Human-Computer Interaction (HCI) and The Internet of Things (IoT) and since the publication of Bleecker’s essay (2009) is now well established as part of the speculative design discipline.

Credited with coining the term speculative design, in their work Dunne and Raby (2013) explore the notion of design fiction as a catalyst for social dreaming. They describe the use of design as a conceptual tool to critically explore the implications of new developments in science and technology and say that designers shouldn’t just look to address the issues of today but must also look into the future and ask how future challenges can be addressed through design, stating, “When most people think of design, most believe it is about problem solving. There are other possibilities for design; one is to use design as a means of speculating how things could be” (Dunne & Raby, 2013, p. 2).

This is certainly true from the perspective of Tanenbaum (2014:22), and Markussen and Knutz (2013) who debate the term’s definition, advocating the need to increase understanding around the use of design fiction as a research approach.

According to Sterling (2012), design fiction is the “deliberate use of diegetic prototypes to suspend disbelief about change” (p.1). This echoes Lindley (2018a) who describes design fiction as concerned with the process of building a fictional realm, where future visions may be brought to life through the process of designing, modelling and prototyping. According to Lindley (2018b) while centrally held notions include a concern with the future, he contests that there is little consensus around the specifics of how each individual term [design and / or fiction] may be defined. As a result, the term has multiple meanings, each determined within and via the context of its use.

## **Design fiction as a design and technology pedagogy**

Within the context of this research, as a notion design fiction was introduced to pre-service teachers while Sterling’s concept was relatively new, hence at the time its primary application was to explore innovative ways in which lecturers at University could inspire the pre-service teachers and encourage them to adopt ‘state-of-the-art’ pedagogic delivery of design within their own practice.

As such, within this paper design fiction aligns with the work as defined by Kirkby (2010; 2011) whose study in the field of development of diegetic prototypes within the field of entertainment has focused upon the contributions made by ‘scientists’ employed by film makers, and the subsequent impact these future designs have had on science and technological developments in the real world.

## **Other studies in this field**

Other than the early work by Bell and Wooff (2012) and Bell and Jones (2013), which documented how design fiction was being used within ITE to support the education and training of design and technology teachers, there is limited work within the field specific to use of design fiction as a catalyst for design within design and technology education.

Prior to the coining of the phrase, based on the notion that design and technology is premised ‘on a notion of what might be rather than what is’, early work by Stables (1992) advocates the use of fantasy as a positive to support young children to engage in creative, designerly activity.

This is similar to the work of McLain *et al.* (2017) who explore the use of design fiction with primary age children. In this example, working within the context of a traditional stories (which also supported links to the development of the children's literacy) the children were encouraged to speculate and use the notion of design fiction to help create a futuristic solution to solve a fictional design problem.

More recently adding to work in the field Hardy (2018) has illuminated the use of design fiction within design and technology within local schools, where the concept has been used to teach children about new and emerging technologies.

## **Methods**

Theoretically underpinned by social constructivism, which aligns with the authors' individual epistemological and ontological positions, this study adopts a relativist paradigm and we recognise the subjective experiences of multiple realities for the participants, and ourselves in relation to social and technological activity (Guba, 1981, 1990). Adopting a collaborative approach, the co-construction of knowledge was encouraged through joint questioning and interpretation which was further informed by samples of both teacher's own and students' work, and through recall of the activity undertaken in the classroom (Bowen, 2009; Stake, 2005).

Documenting work undertaken by pre-service teachers who completed their undergraduate teacher education programmes between 2008 and 2012, this paper engages a small number of those students (n=9) to examine for analysis the impact of this aspect of their teacher training has had on and in their practice. As such this study's findings may be considered to fall within the field of practitioner enquiry (Baumfield & Wall, 2012), and the approach adopted was one informed by case study, which are a long-established method of documenting phenomena, across a range of disciplines (Merriam, 1998; Stake, 2005).

The participants had been pre-service teachers training to become secondary age (children aged between 11 and 18 years old) design and technology teachers between 2008 and 2012. At the time of engagement in this study, all were employed within their respective institutions as teachers of design and technology. Prior to participation the aims and purpose of the study were explained to participants and informed consent obtained. Data collection took the form of semi-structured interviews, which were akin to conversations with a purpose (Kvale & Brinkmann, 2009, 3), with follow up email discourse. Interviews took place in a neutral setting, and always adhering to ethical guidance outlined by the British Educational Research Association (BERA, 2018). Interviews were undertaken in accordance with procedures advocated by Bowden and Green (2005), recorded and transcribed verbatim, with care taken to accurately record responses when creating the vignettes in order to avoid misrepresentation.

## **Findings**

Following analysis of the data, which was conducted in accordance with procedures advocated by Braun and Clarke (2013) and Finch (1987), three vignettes were developed from participants' responses to present aspects of the findings as a whole. The vignettes represent participants' perceptions of their experiences in using design fiction as a catalyst to support the effective delivery of design within design and technology, and how subsequently they have sought to use it, within their own practice. For context each vignette describes briefly the participant's background, and where appropriate their perceptions on learning, personal development and related practice within their respective settings.

### *Vignette One*

Now in her 11<sup>th</sup> year of service, Head of Department Traci continues to use design fiction not only in her own teaching but encourages her departmental staff to do the same. In this vignette Traci explains how she utilises design fiction within her own specialist area, technological textiles.

...I was captivated by the work at University, it wasn't so much the sci-fi films, but more when we explored how film has influenced design trends, particularly apparel textiles. My favourite has to be one of Alexandra McQueen's recent collections, the homage to 'Blade Runner'. It makes you really stop and think, and question who is the designer?.

She goes on,

Building upon my previous experience (working within the textiles industry) and the development of Personal Protective Equipment (PPE), I'm particularly interested in STEM and the innovation application of new materials within technological textiles. I recall being shown a video interview with the designer of the police uniforms from the film 'Robocop' and thinking wow! Based upon this, combined with materials such as Kevlar and D30 I use this as an example within my teaching all of the time.

The beauty behind design fiction is that the children don't have to make a fully functioning working product and they can therefore focus more on the development of other skills, which can be iterative design, the quality of finish or it gives an opportunity to experiment and actually learn about the materials they could use, or materials that need to be designed!

In designing products for the future, we have explored PPE, wearable technologies (including integrated sound systems) and in one recent project, aware that Kevlar doesn't protect the wearer from a blade, one pupil has been designing new clothing to help address knife crime... and as an additional benefit we have seen a significant rise in the number of boys opting for the subject [beyond compulsory schooling].

### *Vignette Two*

Now in his 8<sup>th</sup> year of teaching, Marc explains how he has been using design fiction as a way not only to help pupils to become more engaged in design, but also to help combat a reduction in curriculum time, equipment and resources.

...We find that the pupils always want to make things, which is good, but with fewer shorter lessons, and not always having sufficient resources the quality of outcomes has been reduced. Also, quite often, because they [the pupils] focus purely on the making they don't always learn a lot. Sometimes we've struggled to get them to design but using design fiction we've been able to encourage them [the pupils] to really get actively involved in all sorts of design activity.

We've found it to be particularly valuable in product design, where thinking hasn't been restricted by the tools, equipment and materials we have available to them. We have been using a lot of computer modelling and simulation but where we have gone onto make a prototype model the focus has been on working to support pupils to develop skills, such as cutting, shaping and forming the materials, and also to help them to focus on getting a really high-quality finish on their work.

Working in this way also helps us to help them to develop their visual design and communication skills. Overall the use of design fiction to help to delivery design lessons makes things much more interesting. We focus on some big themes such as transport, environment and communication and have found that when considering the 'human aspects' of technology girls become more interested that perhaps were previously.

### *Vignette Three*

In this third and final study Ryan, Head of Food Technology, in his 6<sup>th</sup> year of teaching, discusses how he uses design fiction within food technology.

At first, when we covered this at University while useful for other material areas, I couldn't really envisage how I would be able to use the notion of design fiction within food technology, however now I don't know how we would cover some of the content of our curriculum without it.

He continues,

... to be honest I didn't use in in my first few years of teaching because it didn't seem to fit with what I was doing. At University we had drawn heavily on film as a catalyst for the original work, which fell within product design, but then out of the blue the 'Hunger Games' was released. It coincided with work some of the pupils were covering in English Literature around 'dystopian' futures - so always trying to work our curriculum to meet the learners' interests we decided to couple both ideas together.

Topics such as sustainability, GM and modified foods, food miles and food provenance, which are interesting to me, but often perceived as quite dull to the students, we found that by adapting the design fiction concept we were able to explore food in a completely different and new way.

He continues,

Within the context of climate change and alternative futures we had pupils exploring what could food look like in the future and how through innovation, food may change. We were able to revisit food preservation, canning, hydration and freezing for example and look at hydrated foods which allowed us to look at possible food preservation techniques for the future. The children always come up with some wild and whacky ideas from food pills, to shrinking and re-hydrate foods, but also to reduce food waste. This often leads back to taste and texture, and eating as a source of nutrition or is it a social and sensory experience? It is an exciting way to stimulate debate. It certainly gets everyone thinking and helps us to cover so much of our curriculum in a new and innovate way!.

### **Discussion**

Analysis makes clear that participants have found the adoption of design fiction within their teaching to be a useful tool to support the effective delivery of design within design and technology education. Participants cited an increase in student motivation to engage in designerly activity, and notably when working within traditionally engendered areas the engagement of the non-dominant gender was increased. Adoption of the notion was perceived as enhancing stimulating meaningful debate, which in turn enabled innovative outcomes that transcended material areas. Activity was perceived to hold numerous advantages, including enabling a focus on thinking and the development of visual communication. Participants recalled design fiction as a concept introduced to them at University, and while it was evident that they had used in numerous ways to stimulate work within their own practice, they hadn't updated their working knowledge of the notion itself. In the decade since completing their teacher training design fiction has become well-established as a valid concept within the field of speculative design and coupled with technological advances in both science and technology, work within the field has developed considerably. Within the context of design and technology as a curriculum discipline in decline (Irving-Bell et al., 2019) the adoption of a paradigm shift in ways of thinking about designerly activity holds considerable potential.



Figure 1. Spime-like devices: Potential meta-history data generation (Stead *et al.* 2019b)

Within the context of speculative design (and design fiction) and the Internet of Things (IoT) Stead *et al.* (2019) advocate an approach to sustainability, which is to build meta-history data into to the design of products (Figure 1). While on the surface there is nothing ‘new’ with this as a concept, when digging deeper their work to develop ‘spimes’ (the neologism used to define a futuristic object which can be tracked throughout its lifetime) as sustainable connected devices, is fascinating. Building upon work originated by Sterling (2005) spime-like devices would generate their own metahistory data, and through the use and adaptation of other emergent technologies such as blockchain (Figure 2) could be used by the conscious consumer to help to facilitate sustainable behaviour.

Blockchain is a record keeping system, used to describe how growing list of digital information are stored. It is frequently used in conjunction with the digital cryptocurrency bitcoin, and the easiest way to understand blockchain is to think of the digital information being stored as a block, and the way (or place) it is stored as the chain (Figure 2). The idea being that within financial transactions for example, when new information is added it is added as a new block, which makes it very difficult to change any of the previous blocks (information) without the need to manipulate other blocks in the chain.

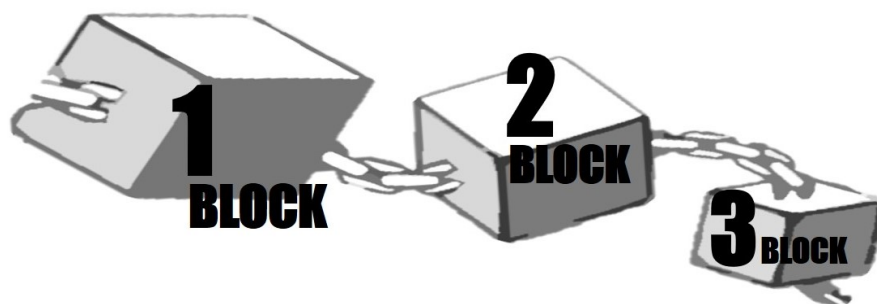


Figure 2. Visualising the notion of blockchain

Within the context of design as explored within this study, the concept of blockchain could be used to support children to understand more fully the wider (global, social and moral) implications their design work may have.

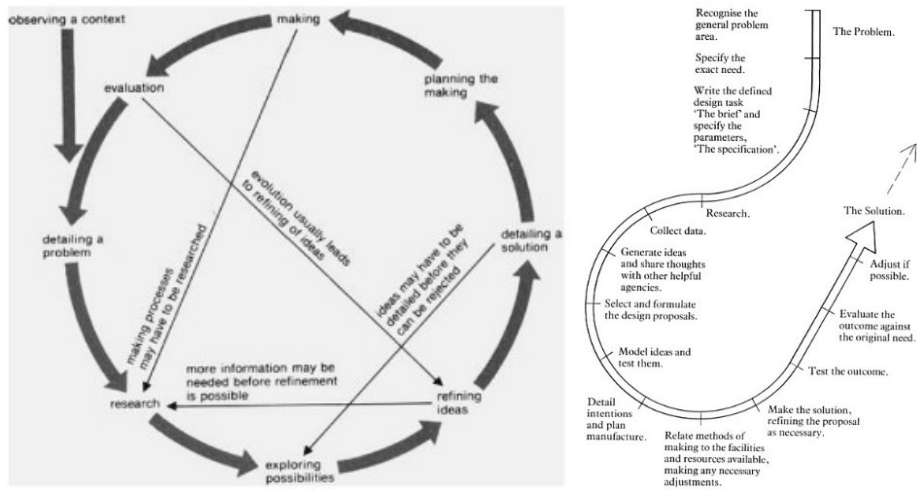
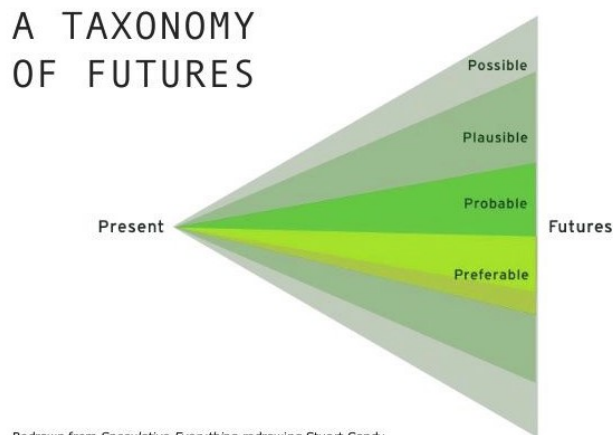


Figure 3. Describing design and technology  
Adapted from Kimbell & Stables (2007, p. 73)

While perhaps an uncomfortable notion for a subject where the focus is to ‘design and make’, bound within wider issues arising from global consumerism, a revised curriculum that advocates approaches that consider the long-term effect that new technologies may have within society could be just what the subject needs.

However how this could be developed and reflected within the design and technology curriculum within schools may prove to be more problematic. One starting point to support teachers to manage change could be to revisit the subject’s well-established pedagogical models of design (Figure 3). To replace them, perhaps with a composite iteration of new ways of thinking, conveyed in new visual representations (Figure 4 & Figure 5).



Redrawn from *Speculative Everything* redrawing Stuart Candy



Figure 4. A Taxonomy of Futures

Based originally on Hancock & Bezold (1994), redrawn from Candy (2010) in Dunne & Raby (2013)

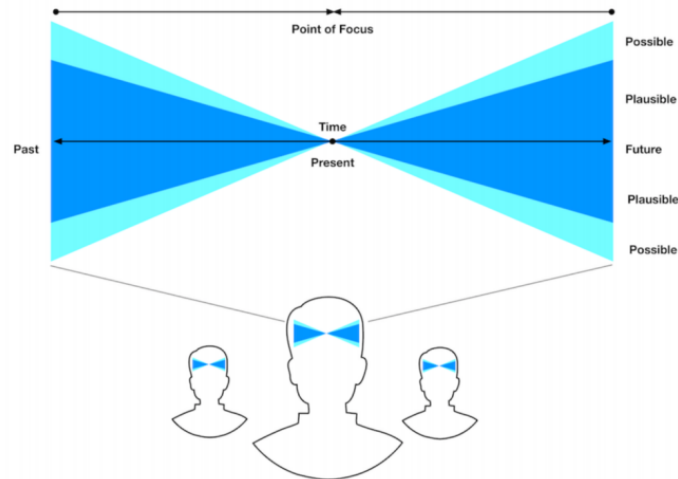


Figure 5. The hermeneutic model of the future (Lindley, 2018, p. 156)

In moving this work forward, next steps would advocate ways in which teachers may be supported to access and develop resources which reflect current thinking within the field of (speculative) design. Particularly with regard to spimes, and the use of new, transformative technologies such as blockchain, to track and trace a new products meta-history and 'asset transparency' (Stead *et al.*, 2019, p.34). To help children to understand the concept of responsible design, to meet the increasing demands of the conscious consumers.

## Conclusions

Early work undertaken for this study sought to embrace the then relatively new notion of design fiction, and findings make clear it is a useful platform from which to instigate and stimulate design debate. However, while some participants have sought to update their knowledge, it is clear that while the field of speculative design has evolved significantly over the past decade, the innovations and developments which could be advantageous to the study of design in schools, have not been as successfully transferred (through teacher education or in-service programmes) into the classroom as perhaps they might.

Embracing new approaches to design thinking may be pivotal in supporting teachers and will be the focus of future work, to support teacher educators of design and technology to re-imagine the subject, its purpose and value within a modern school curriculum (Irving-Bell *et al.*, 2019).

## References

Barlex, D. (2017). Design and Technology in England: An Ambitious Vision Thwarted by Unintended Consequences. In M.J. de Vries (ed.), *Handbook of Technology Education*, Springer International Handbooks of Education, DOI 10.1007/978-3-319-38889-2\_11-1

- Baumfield, V., Hall, E., & Wall, K. (2012). *Action research in education: Learning through practitioner enquiry*. Sage.
- Bell, D., & Wooff, D. (2012). Increasing Student Engagement and Attainment through the Implementation of Technology Enhanced Learning. *D&T Practice: The Design and Technology Publication for the Profession*, (3), 16-19.
- Bell, D., & Jones, R. (2013). Exploring Augmented Reality. *D&T Practice: The Design and Technology Publication for the Profession*, 1, 15-17.
- Braun, V. & Clarke, V. (2013). *Successful Qualitative Research: A Practical Guide for Beginners*. Sage.
- British Educational Research Association [BERA] (2018). *Ethical Guidelines for Educational Research*, fourth edition, London. Available at: [https://www.bera.ac.uk/wp-content/uploads/2018/06/BERA-Ethical-Guidelines-for-Educational-Research\\_4thEdn\\_2018.pdf?noredirect=1](https://www.bera.ac.uk/wp-content/uploads/2018/06/BERA-Ethical-Guidelines-for-Educational-Research_4thEdn_2018.pdf?noredirect=1) Last accessed 30<sup>th</sup> April 2019.
- Bleecker, J. (2009). Design Fiction: A short essay on design, science, fact and fiction. Near Future Laboratory. <http://blog.nearfuturelaboratory.com/2009/03/17/design-fiction-a-short-essay-on-design-science-fact-and-fiction/> Last accessed 29<sup>th</sup> April 2019.
- Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative research journal*, 9(2), 27-40.
- Candy, S. (2010). *The futures of everyday life: Politics and the design of experiential scenarios*. (Doctoral dissertation, University of HAWAI 'I AT MĀNOA). <https://www.benlandau.com/wp-content/uploads/2015/06/Candy-2010-The-Futures-of-Everyday-Life.pdf> Last accessed 10<sup>th</sup> May 2019.
- Cultural Learning Alliance (2018). *Ofqual publish GCSE and A Level entry numbers for 2018* (8 June 2018). <https://culturallearningalliance.org.uk/ofqual-publish-gcse-and-a-level-entry-numbers-for-2018/> Last accessed 5<sup>th</sup> May 2019.
- de Vries, M. J. (2007). Philosophical reflections on the nature of design & technology in Barlex, D. (Ed.). (2007). *Design & technology: For the next generation: A collection of provocative pieces, written by experts in their field, to stimulate reflection and curriculum innovation*. Cliffeo Limited.
- DfE (2015). *Design and Technology GCSE Subject Content*. <https://www.gov.uk/government/publications/gcse-design-and-technology> Last accessed 5<sup>th</sup> May 2019
- DfES (2004). *Key Stage 3 National Strategy, Foundation Subjects: design and technology framework and training materials*. London: HMSO. <https://webarchive.nationalarchives.gov.uk/20110213101149/https://nationalstrategies.standards.dcsf.gov.uk/node/97671> Last accessed 1<sup>st</sup> May, 2019
- Dunne, A., & Raby, F. (2013). *Speculative everything: design, fiction, and social dreaming*. MIT press.
- Ellen Macarthur Foundation (2011). *Project Redesign: taking the circular economy into schools*. <https://www.ellenmacarthurfoundation.org/our-story/milestones> Last accessed 30<sup>th</sup> April 2019.
- Finch, J. (1987). The vignette technique in survey research. *Sociology*, 21(1), pp. 105-114.

- Guba, E. G. (1981). Criteria for Assessing the Trustworthiness of Naturalistic Inquiries. *Educational Communication and Technology*, 29(2), 17.
- Guba, E. G. (1990). The Alternative Paradigm Dialogue. In E. G. Guba (Ed.), *The Paradigm Dialogue*. London: SAGE.
- Hancock, T. and Clement, B. (1994). Possible futures, preferable futures. *Healthcare Forum Journal*, 37(2), 23-29.
- Hardy, A. (2018). Using design fiction to teach new and emerging technologies in England. *Technology and Engineering Teacher*, 78(4), 16-20.
- Irving-Bell, D., McLain, M., and Wooff, D. (2019). Re-designing Design and Technology Education: A living literature review of stakeholder perspectives. Conference Paper in Developing a knowledge economy through technology and engineering education. PATT 37 Conference, University of Malta, 3<sup>rd</sup>-6<sup>th</sup> June 2019. In Press.
- Kimbell, R., & Stables, K. (2007). *Researching design learning: Issues and findings from two decades of research and development* (Vol. 34). Springer Science & Business Media.
- Kirby, D.A. (2011), *Lab Coats in Hollywood: Science, Scientists, and Cinema*, Cambridge, MA: MIT Press, ISBN 9780262518703.
- Kirby, D. (2010). The Future is Now: Diegetic Prototypes and the Role of Popular Films in Generating Real-world Technological Development. *Social Studies of Science*, 40(1), 41–70. <https://doi.org/10.1177/0306312709338325> Last accessed 1<sup>st</sup> May 2019.
- Kvale, S., & Brinkmann, S. (2009). *Interviews: Learning the craft of qualitative research interviewing*. Sage.
- Lindley, J.G. (2018a). What is Design Fiction? This is Design Fiction as World Building. [https://www.youtube.com/watch?time\\_continue=15&v=Qj0xkynMTJc](https://www.youtube.com/watch?time_continue=15&v=Qj0xkynMTJc) Last accessed 30<sup>th</sup> April 2019
- Lindley, J. G. (2018b). A thesis about design fiction. Lancaster University. <http://eprints.lancs.ac.uk/129788/1/2018JosephLindleyPhD.pdf> Last accessed 30th April 2019.
- Linehan, C., Kirman, B. J., Reeves, S., Blythe, M. A., Tanenbaum, J. G., Desjardins, A., & Wakkary, R. (2014). Alternate endings: using fiction to explore design futures. In *CHI'14 Extended Abstracts on Human Factors in Computing Systems* (pp. 45-48). ACM.
- Markussen, T. and Knutz, E. (2013). 'The poetics of design fiction', Proceedings of the 6th International Conference on Designing Pleasurable Products and Interfaces - DPPI '13. New York, New York, USA: ACM Press, p. 231. <http://dl.acm.org/citation.cfm?doid=2513506.2513531> Last accessed 1<sup>st</sup> May 2019.
- Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from " Case Study Research in Education."*. Jossey-Bass Publishers, 350 Sansome St, San Francisco, CA 94104.
- McDonough, W. & Braungart, M. (2002) *Cradle to Cradle: remaking the way we make things*. New York: North Point Press.

McLain, M., McLain, M., Tsai, J., Martin, M., Bell, D., & Wooff, D. (2017). Traditional tales and imaginary contexts in primary design and technology: a case study. *Design and Technology Education*, 22(2), 26-40.

TBD Calatlog (2019). Near Future Laboratory <http://tbdcatalog.com/>. Last accessed 10<sup>th</sup> May 2019.

Stables, K. (1992). The role of fantasy in contextualising and resourcing design and technological activity. IDATER 1992 Conference, Loughborough: Loughborough University. <https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/1610/3/stables92.pdf> Last accessed 30<sup>th</sup> April 2019.

Stake, R. E. (2005). Qualitative Case Studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (pp. 443-466). Thousand Oaks, CA: Sage Publications Ltd.

Stead, M., Coulton, P., & Lindley, J. (2019a). Spimes Not Things: Creating A Design Manifesto for A Sustainable Internet of Things, in the Proceedings of the European Academy of Design 2019.

Stead, M, Coulton, P, Lindley, J and Coulton, C. (2019b). The Little Book of Sustainability for the Internet of Things, PETRAS Little Book Series, Imagination, Lancaster University. ISBN 978-1-86220-360-0. Retrieved from [http://eprints.lancs.ac.uk/131084/1/Stead\\_Coulton\\_Lindley\\_Coulton\\_2019\\_The\\_Little\\_Book\\_of\\_Sustainability\\_for\\_the\\_Internet\\_of\\_Things.pdf](http://eprints.lancs.ac.uk/131084/1/Stead_Coulton_Lindley_Coulton_2019_The_Little_Book_of_Sustainability_for_the_Internet_of_Things.pdf) Last accessed 29<sup>th</sup> April 2019.

Sterling, Bruce, 2005, *Shaping Things*. Cambridge, MA: Mediawork / MIT Press.

Sterling, B. (2012). Bruce Sterling Explains the Intriguing New Concept of Design Fiction (Interview by Torie Bosch) Slate. <https://slate.com/technology/2012/03/bruce-sterling-on-design-fictions.html> Last accessed on 10<sup>th</sup> May 2019.

Tanenbaum, J. (2014) 'Design fictional interactions', *Interactions*, 21(5), pp. 22–23. doi: 10.1145/2648414.

Trigwell, K. (2002). Approaches to teaching design subjects: a quantitative analysis. *Art, Design & Communication in Higher Education*, 1(2), 69-80.