

Applying Design Fiction in Primary Schools to Explore Environmental Challenges

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Abstract: This paper presents a case study describing the use of design fiction in a cross-curricular project with four classes across two primary schools in inner-city Sheffield. The project combined elements of a Mantle of the Expert dramatic-inquiry approach with design thinking and design fiction, to explore the world of the honey bee. We worked with the schools and children during half a term, leading them through a set of activities (including drama, design, creative writing, and 3D prototyping) to enable the children to discover and understand the threats facing bees, beekeeping, pollination, and the global environmental ramifications of a world without bees. This paper describes the approach adopted and the created design fictions. We discuss the value and limitations of our approach and conclude by offering suggestions for researchers and teachers wishing to engage young people with complex problem spaces.

Keywords: Design fiction, Speculative design, Primary education, Mantle of the expert, Environment

1. Introduction

Climate and environmental changes are becoming increasingly visible in mass media, activism (e.g. the UK based Extinction Rebellion movement) and, unsurprisingly, in the proliferation of noteworthy weather events. Children and young people face an uncertain future as our changing climate is forecast to have an increasingly detrimental impact on our daily lives. Whilst their voices are beginning to be heard (e.g. Haynes and Tanner, 2015), it is important that they are able to understand, critically engage with and reflect upon the changes being wrought, such that they become empowered to act positively and knowledgeably. We argue that a design-led study of the humble honey bee, often seen as an indicator for environmental health (Porrini et al, 2003), can be an accessible and positive way in to consider and open up discussions of wider environmental concerns.

Honey bees, along with other insect pollinators, are vital for pollination globally and hold a prominent role Western culture, from Manchester's citywide symbol of industriousness and strength, to novels such as Laline Paull's *The Bees* (2014) and Maja Lunde's *The History of Bees*

(2017), and a plethora of bee products (including Manuka honey, antibacterial propolis and venom infused moisturisers). The work reported in this paper was part of the Telling the Bees project, which sought to explore past, current and future narratives about bees and beekeeping through the use of design (e.g. Maxwell et al 2016). To prompt discussion and debate, our future narratives were informed by the use of speculative design (Edwards et al 2016).

In this paper we present a case study describing the use of design fiction in two primary schools in England to enable the children to discover and understand the threats facing bees, beekeeping, pollination, and the global environmental ramifications of a world without bees.

2. Background

Design Fiction is a form of speculative design whereby prototypes are used to think about futures (Bleeker, 2009; Sterling, 2012), the idea being that “positioning an imagined technology within a narrative world requires a designer to think beyond the immediate implications of that technology and consider it within a broader social and cultural narrative” (Tanenbaum et al., 2017). Following its inception, the concept has been used by researchers and designers in various ways (Coulton et al., 2017), but often involves the use of diegetic prototypes (Kirby, 2010); artefacts that might live believably within a fictional world. The designs act as “entry points” (Ibid.) into the imagined future worlds. Supporting materials, such as advertising materials or instruction documents for the fictional objects, are hooks that add to the richness of the world, give credence to the fictions and reveal more details about how the designs exist within that world. This realistic rendering of an imagined future world prompts reflections on the implications of particular designs, encourages questions about the world in which that design fiction exists, and challenges us to consider how a plurality of future worlds might emerge from our present and past (cf. Coulton & Lindley 2017).

Design Fiction has been used previously in the context of sustainable futures (Hauser et al., 2014; Tanenbaum et al., 2016; Tanenbaum et al., 2017). In terms of applying Design Fiction in educational contexts, there is no documented use within primary schools, although it has been applied within Higher Education (Hauser et al., 2014) and secondary schools. In the latter example, Design Fiction was mobilised as a participatory method to explore possible educational futures (Duggan et al., 2017). Over a six-week period, children between the ages of 13-14 used a range of techniques including discussion, short stories, comic strips and ‘photovoice’ methods to envision future scenarios for their own school several years in the future. However, the project was abandoned due to ethical concerns relating to the content of the design fiction and the consequent loss of support from teachers collaborating in the project.

In more traditional design and HCI fields, a body of work addresses children's participation in the design of novel technologies (e.g. Fitton, 2015; Fitton, 2016). Fitton's work positions children as “young designers” using design skills like scenario sketching for ideation and introduction to digital technologies. This research is situated in participatory design, which emphasises the role of participants as ‘experts’ in their experience. Iverson's (2017) concept of design protagonists aims to empower children in developing technology and critically reflecting on their designs. Other research focuses on children's maker skills, programming competencies and design identity (e.g. Iivari, 2018). For the specifics of 3D printing, Berman (2018) has shown how a casual maker approach can be used to engage primary school students in a simplified 3D printing process.

3. Methods

In *Telling the Bees* we worked with four classes of Year 5 primary school children (over 80 pupils, age 9-10) across 2 schools in inner-city Sheffield, hereafter referred to as School 1 and School 2. These schools are situated in areas of acute deprivation; for example, at School 1 66% of children are eligible for free school meals. This raises a number of barriers to learning: high proportions of children are designated with Special Educational Needs, parental aspirations tend to be low, and there is higher than average pupil mobility. The schools aim to provide rich cultural experiences that might not be available at home, and which provide opportunities for first-hand learning. Additionally, they are committed to tackling poorly developed verbal skills and low self-esteem. With these issues in mind, and prior experience of working with our partner GrowTheatre, both schools were keen for us to work with their Year 5 children, when they are just beginning to develop their independent learning and team working. In terms of logistics, this also avoided the problems of working with the older Year 6 children, who had SATs exams and were preparing for secondary school.

Both schools joined the project during a single half term in summer 2017, but in School 1 the activities were condensed into a week of intensive engagement, while in School 2 they were spread out over the course of the whole half term. While we undertook to give each school a similar set of activities and experiences, these different chronologies and intensities of engagement yielded slightly different outcomes and affordances; in particular, they affected to what extent the teachers could incorporate the project themes into their wider teaching.

In both schools, we incorporated the project activities into the core curriculum as part of the normal school day, and parental permission was sought via the schools to collect and use any data (e.g. photographs, written classwork). Data was gathered throughout the project, mostly in the form of documenting the children's classwork in various media, but it also included an anonymised, game-based baseline evaluation from children at the first event, and similar reflective anonymised written feedback in the last classroom activity. In addition, teachers from both schools were interviewed a few weeks after the class-based work ended.

An important part of our approach, and one which the schools were attracted to, was that we developed Design Fictions in combination with elements of the Mantle of the Expert teaching method. This method, which involves learners roleplaying as experts in a particular field, is rooted in three pedagogic structures – inquiry learning, drama for learning and expert framing – that puts the emphasis on learning that is “child-centred” but not child-led (Aitken, 2013). At its heart is a philosophy that values the “dialectic processing of information” through social interaction and active participation in groups (Heathcote & Herbert, 1985). Becoming an expert involves learning how to see the world from a knowledgeable perspective, and developing the skills needed to make good decisions. This challenges traditional roles in education in which learners are “passive receivers of knowledge” and teachers hold power as the “giver of knowledge” (Aitken, 2013). The application of drama techniques – such as role-play – is intended to help reposition the *learner* as an expert and the teacher as *facilitator*, enabling a process of self-directed research and discovery.

In partnership with professional actors and experienced theatre practitioners, and reflecting the commitment within Mantle of the Expert to a holistic approach to education, these performative elements were used throughout the project to support and enrich the learning process. To that end, we developed a narrative core around which the designing and making activities were contextualised: the children were asked to form imaginary design companies that were being consulted on ways to address catastrophic declines in the honey bee population in a near future where bees were either a) extinct, or b) extremely rare. Each group was to produce an imaginative

product design that would provide a solution to alleviate one of the consequences of the lack of bees.

In some ways, the overall design arc followed a conventional double diamond process (Design Council, 2007), with early activities focusing on defining the problem and exploring the background context. This involved an initial field visit to the National Trust’s Clumber Park estate where, with the support of the Gardens Team, we hosted a series of introductory activities that included drama games, a talk and observation hive viewing with a beekeeper, and a talk about pollination within the walled garden orchard. Unsurprisingly this field trip, to a place that might otherwise have been inaccessible to many of the children, proved to be one of the most popular of the project’s activities.

Back in the classroom, conventional design tools – including mood boards, sketching and storyboarding templates – were used to help explore the possible causes and implications of catastrophic bee decline, and develop ideas for potential solutions (see Figure 1). Once each group had settled on an idea, they all took part in a structured peer critique session to enable them to refine their ideas further and practise the art of presenting and giving and receiving feedback. These design tools and techniques were blended with drama and role-play activities. For example the peer critique took the form of a *Dragons’ Den* (BBC TV) style performative pitch, while their completed designs were the subject of a filmed news report. Throughout the process and idea development, informal feedback from the project team and teachers aimed at opening up and pushing the ideas further through questions about how and why the designs functioned, rather than closing down imaginative aspects.

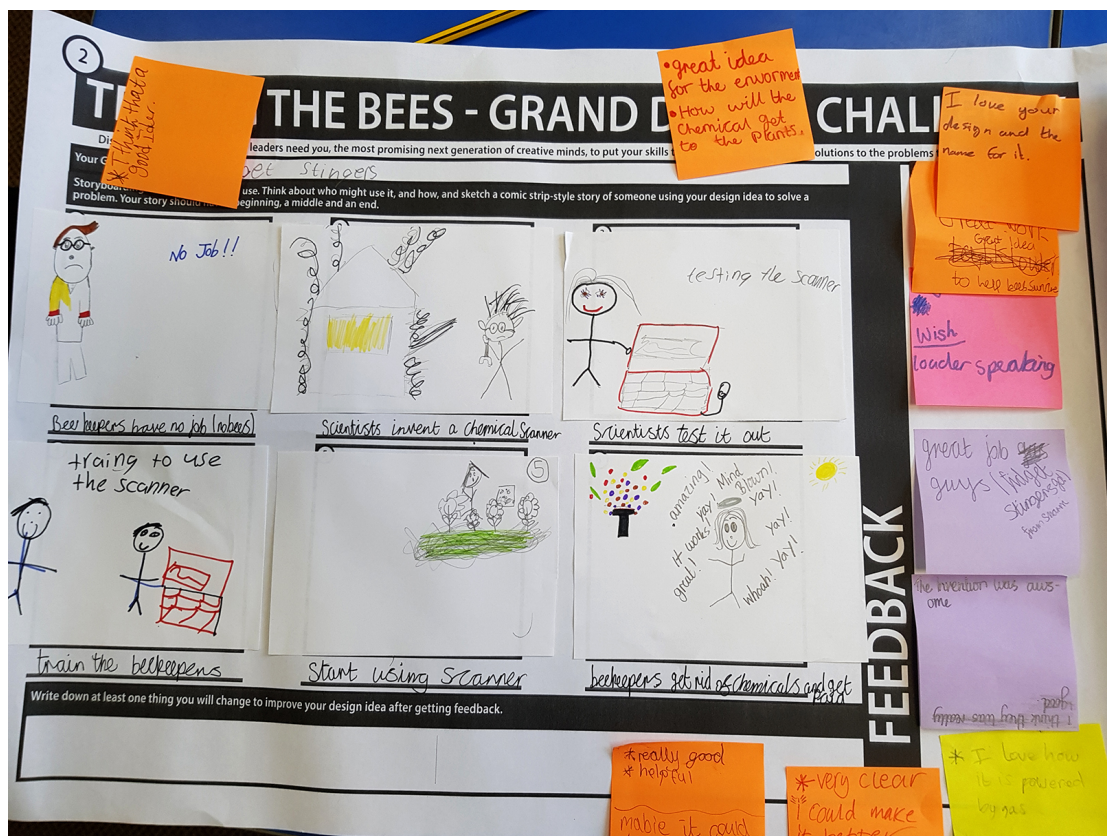


Figure 1. Design template for The Chemical Scanner concept showing storyboard cells and written feedback from the rest of the class on post-it notes (from structured peer critique session).

In addition, to develop children’s writing skills and expand the fictional world inhabited by their prototypes, each group worked together to create their own newspaper that included photographs

of their drama pieces, written reports of their ideas, creative writing in the form of poetry and jokes, and illustrations of their design (e.g. as an advert). These were collated, transcribed and printed up into a complete set of newspapers for each class (e.g. see Figure 2).

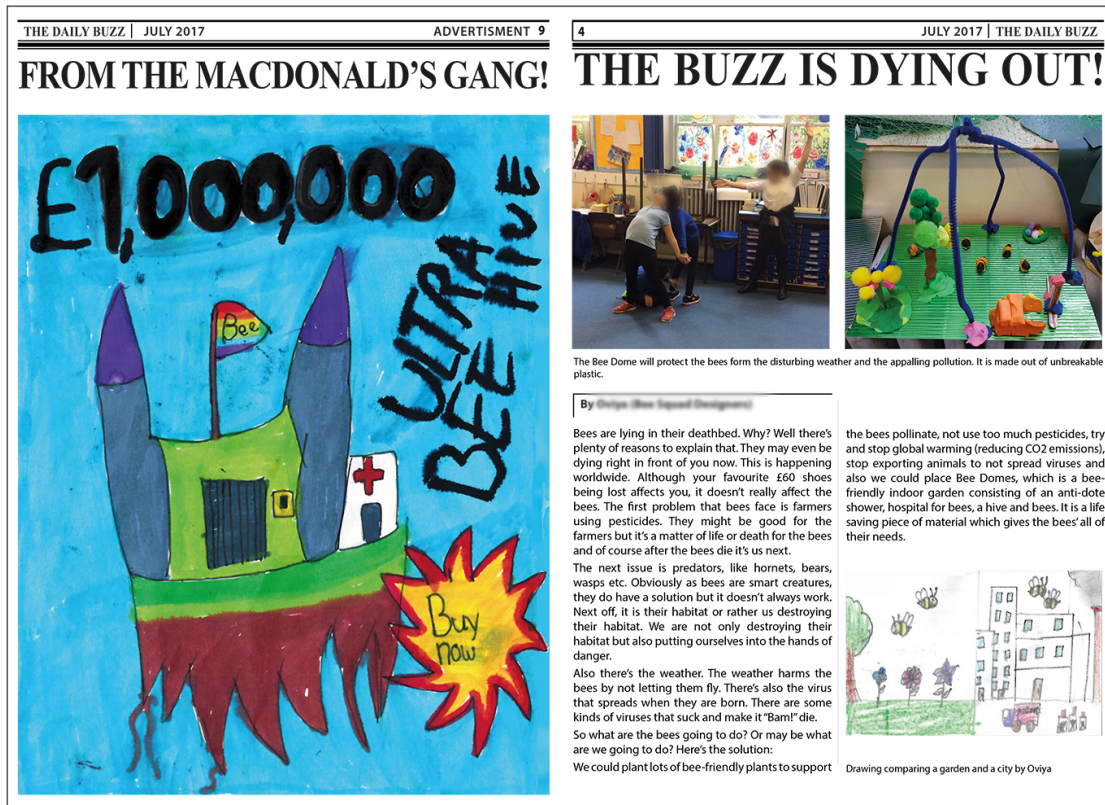


Figure 2. Sample images from the school newspapers created by the children illustrating a) an advert for the Ultra Beehive design (lhs) and b) an article describing a bee dome design with images from drama activities, a sketch and lo-fi model of the dome.

To finalise their designs, the children produced technical drawings before creating lo-fi physical artefacts. Following this, and to support the development of digital design and making skills, each group used open source 3D modelling software to create artefacts that could be 3D printed (see Figure 3). It was initially intended that these artefacts would be digital versions of their designs, but the approach was changed after working with the two classes at School 1 – the children simply did not have the skills nor the time to convert their physical models to digital form. Instead, pupils at School 2 produced digital designs of futuristic bee-friendly flowers and pollen. These displayed an array of characteristics that reflected their subject learning; for example, flowers that had appendages that provided shelter from the rain, and pollen that was designed to adhere more easily to foraging bees.

The 3D prints were then exhibited, along with each class' newspapers, at our project partner organisation, York Explore Library. A hive-shaped display case was constructed, which incorporated a digital display and sensor system, such that placing each design on a plinth would trigger (via NFC tags) a video animation telling the story of how it would support honey bees, or help us cope in a world where they no longer existed (Figure 4). All four classes participated in a final field trip to York where they were able to see their work exhibited.



Figure 3. Lo-fi model of the Bee Armour design (lhs) modelling protective armour on her wings and feet, and the plasticine model sporting the 3D printed armour artefact (rhs).



Figure 4. Interactive Exhibition Hive display case showing a) all the 3D printed design fictions and the screen (lhs) and b) close up of the shelf containing a near field communication (NFC) reader underneath it with a design fiction placed on the shelf.

4. Design Fictions

Between the four classes, 19 designs were created and rendered as final 3D printed prototypes. The physical prints, whilst evocative, were in many cases rather visually abstract with their intention and intended functionality not always immediately apparent. Therefore, in order to provide some explanatory interpretation, the interactive exhibition case was created (Figure 4). The use of single colour PLA prints (a necessary limitation of project resources) impacts the believability of the artefacts as design fictions – they lack scale and appear somewhat simplistic and toy-like. However, the material similarities across artefacts imbued a sense of coherence; of being part of a collection.

Table 1 summarises the designs that the schoolchildren created. There was some notable overlap in ideas; most obviously three variations on a ‘bee dome’ (arising independently across different classes

and schools), where bees could live in safety from predators and parasites (similar to the Eden Project or even The Truman Show). One of these designs had an additional twist, in that it incorporated a network of mobile tubes extending out from the main dome, allowing bees to fly safely and directly to foraging sites. Whilst there was not such obvious similarity in some of the other ideas, there were definite commonalities in themes of providing safe spaces for bees to rest in (see 4 & 5 in Table 1), and creating technologically advanced secure hives (see 6-8 in Table 1).

Table 1. Summary table of all 19 design fictions describing the ideas and grouped by similarity of themes

	Name	Class ID	Description	
1	Honey Sauce Dispenser	SCH1/B	Synthetic honey product that contains a tiny amount of genuine honey	
2	Laser Bee Wash	SCH1/B	Laser bee wash removes parasites from bees when they enter the hive	These similar ideas emerged from different schools
3	Bee Ultralizer	SCH2/B	A shower for bees that kills parasites	
4	Safe Spaces	SCH2/B	A welcoming habitat for bees that find themselves stranded in cities	
5	Hive Hotel	SCH1/A	A safe space for bees to live and rest, with its own security system to make sure only bees can enter	Similar ideas on bee habitats from different schools
6	Beeshield	SCH2/B	A security system for hives that prevents infected insects and invaders from entering	Designs to create secure hives
7	Ultra Beehive	SCH1/A	A safe and fortified beehive	
8	The Net	SCH1/B	The net is placed over the hive to stop parasites entering	
9	Beetopia	SCH2/A	A huge covered dome to protect safe, includes a sugar water river, flowers and beehives	3 bee dome ideas from different classes and schools
10	Bee Dome	SCH2/B	A large covered dome to protect bees from disruptive weather and pollution	
11	Powerful Dome	SCH1/A	A large covered dome to protect bees, with mechanised tubes for bees to visit flowers outside the dome	
12	Virus Extractor	SCH2/A	A handheld virus extractor spray for plants. Visiting bees take up the sprayed pollen that kills parasites when the bees return to their hive	Designs that address chemicals and pesticides
13	The Chemical Scanner	SCH1/B	A handheld scanner that sucks up bad chemicals in plants that kill the bees	
14	Antidote Flower	SCH2/A	An antidote flower with crushed tablets in the middle	
15	Bee Armour	SCH1/B	To protect bees from battles and dying	
16	Honey Machine	SCH2/B	A sorting machine that cleans chemicals from pollen and honey that bees can recollect	
17	The Shop Hive	SCH1/A	A beehive design for shops to increase bee colonies and reduce cost of honey	Service design idea

18	Bee Backpack	SCH2/A	A robotic bee that infiltrates the hive and sprays the bees to deal with parasites	
19	Bee Ray	SCH1/A	This potion shrinks a person to bee size to be able to teach the bees how to defend themselves against predators	This design sits within the realms of sci-fi and fantasy

The designs can be evaluated in a variety of ways, ranging from assessments of their success as examples of design fiction (e.g. their ability to a) suspend disbelief, b) provoke discussion and c) be situated in a near future world) or how successful the process was at engaging school children (e.g. as reflected in enthusiasm, thoughtful design, productive group working), to how beneficial the overall design process was for the schools themselves (e.g. in terms of meeting curriculum objectives and supporting wider teaching activities).

However, as a means to visually consider the ideas as a single cohort, the oft-cited *future cones* diagram (e.g. Coulton & Lindley, 2017) offers a ready tool to examine the children’s work from a design fiction perspective. Figure 5 shows how the designs map to the future cones, their horizontal position reflecting the timeframe in which the design might be made real, from present to far in the future, and their vertical position indicating the likelihood of the design actually existing, from probable to possible futures. Exemplar design fictions would generally sit within near future and possible sections of the diagram.

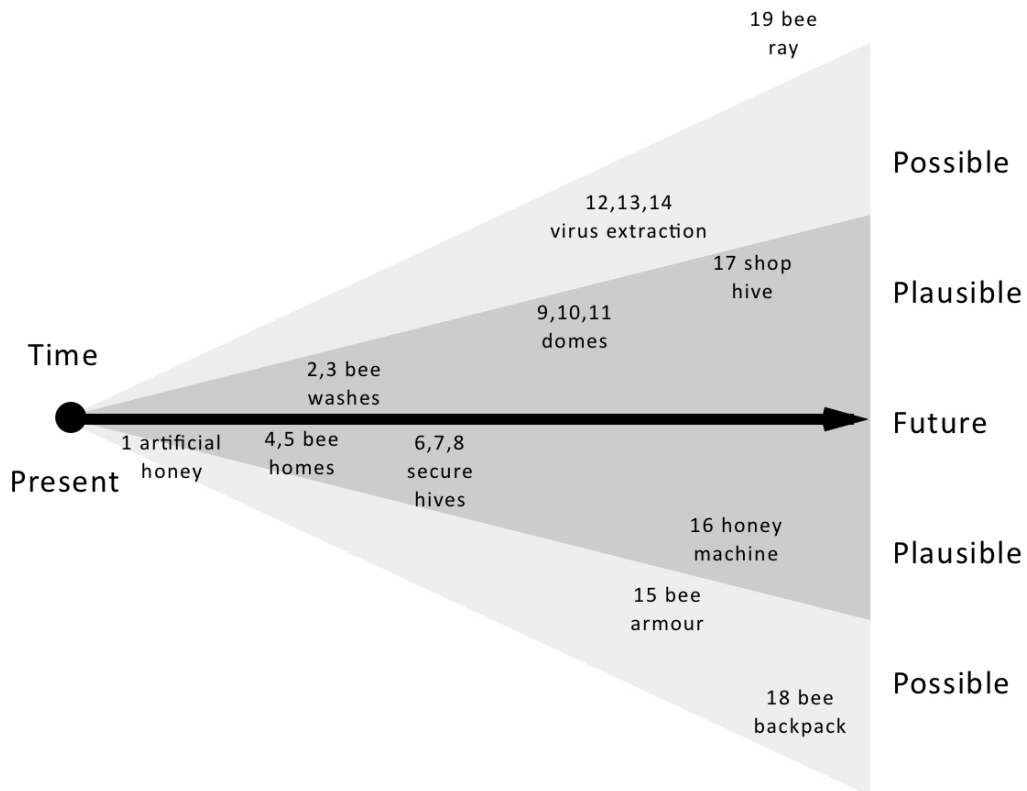


Figure 5. Design fictions mapped to the futures cone (adapted from Coulton & Lindley, 2017). Numbers relate to ordering in Table 1.

It is worth noting the spread of designs across the cone, from ideas that, in various forms, are very near future and almost in existence, to those that are very unlikely. In one case, the Bee Ray, extends beyond the cones of possible futures into the realm of science fiction and fantasy. It is also worth noting that the children were not explicitly tasked with creating design fictions, i.e. they were not told what design fictions are, but rather simply asked to create designs for a future world in which bees had either become extinct or drastically reduced in numbers. Throughout the design process, the project team constantly encouraged the children to develop their ideas further developed; for example, by asking how something might work or what materials might be used. Care was taken not to inhibit, restrict or otherwise harshly critique the children's imaginings. However, one exception to this came when we observed a well-meaning teacher dissuade a group from pursuing a fairly radical, yet interesting design idea, on the basis that it was too unrealistic and silly.

The rest of this section presents three diverse examples of the children's designs.

4.1 Artificial Honey

This design was created in response to a future scenario in which all honey bees had become extinct. The children hypothesised that this loss would lead to huge increases in the price of remaining honey. In order to deal with this imbalance in supply and demand, they created a proposal for Honey Sauce – a synthetic form of honey that contained a minuscule amount of genuine honey to give it an air of authenticity. Their 3D printed design was a model of the Honey Sauce dispenser (Figure 6).

Viability of design fiction:

This design works well in terms of its believability; it is easy to see how this product may arise through simple economic logic, and it would be trivial to realise technically. The design fiction is also set firmly within a future that we will likely enter. Arguably, it is already with us: artificial honey already exists, both illicitly and on the small print of jars of honeycomb (e.g. "Honeygate: How Europe is being flooded with fake honey", 2018). This design is set apart from most of the designs in the project, in that it is relatively abstract. The physical artefact (produced as a requirement of the task they had been set) was not necessarily the best output for conveying the design idea. Indeed, a set of advertising materials may have been more appropriate in this instance.



Figure 6. The Honey Sauce artificial honey design, illustrating a) The junk modelling prototype showing how the Honey Sauce might be manufactured and b) the 3D printed artefact of the top of the sauce dispenser.

4.2 Bee Washes

Two of the designs (from different schools) related to bee washes. These devices would attach at the entrance of beehives, where they would remove any unwanted parasites or pesticide residues from the bees as they enter the hive. One of these took the form of a shower, while the other was a laser that detected parasites and vaporised them (see Figure 7). These ideas reflected class learning about the growing numbers of parasites and pests troubling honey bees in the UK, including the endemic varroa destructor mite and the threat of the small hive beetle.

Viability of design fiction:

This design concept is firmly situated within the near future section of the diagram, and on the border between the probable and possible futures. Whilst to our knowledge, a laser bee wash does not currently exist, there are comparable products that the children were not aware of. For instance, the bee gym (Figure 8) is a small plastic frame with wires strung across it. Bees voluntarily pass between the wires to knock varroa mites from their bodies. An electronically operated door to a beehive would be feasible: there is only one entrance and exit in a conventional beehive, which beekeepers already control by making it narrower towards the end of summer to help bees guard against wasps, and by fitting mouse guards before winter. Moreover, electronic doors exist for other livestock and pets, including hen houses and cat flaps. While a bee door and cleansing system would require very rapid and accurate opening and closing, this could be technically realised, perhaps in part using computer vision and machine learning.



Figure 7. Junk model showing the laser wash and a happy, parasite free bee.



Figure 8. Bee Gym (from <http://www.beegym.co.uk>)

4.3 The Shop Hive

The Shop Hive had a similar starting point as the Artificial Honey: that there were few honey bees left in the world, leading to honey becoming exceptionally expensive. This group's solution was not so much an artefact or product, but rather a service or policy design. In their future, each shop would legally be required to keep a beehive on their premises. This would hopefully rescue and reinvigorate the bee population, thereby introducing new supplies to market that would bring down the cost of honey. When the group was asked to develop a physical model representing their idea, they were initially stumped. Their design did not necessarily require a physical artefact to help explain it. Indeed, this level of abstraction was something that the project team did not anticipate. The group eventually settled on creating a prototype for a hive that could be installed in shops (see Figure 9).

Viability of design fiction:

The prototype hive was certainly not the strongest in terms of its potential technical feasibility. Little thought went into the design of the hive in terms of its affordances and features. This was somewhat disappointing given that recent innovations in hive design suggest this would have been a fruitful area of investigation and imaginative thinking (e.g. the Flow Hive, 2018). Nevertheless, the strength of this design is in its underlying social concept. Beekeeping in urban and indoor environments is becoming increasingly popular, and some of the emerging commercial and concept designs speak to this audience (e.g. BEEcosystem, 2018 and Philips Urban Beehive, 2018). While the Shop Hive is technically possible, the design itself located quite far into the future and deep into the realm of possible, rather plausible, futures. This is due primarily to the unlikelihood of the legislation being created and brought into effect.



Figure 9. The Shop Hive design concept, illustrating a) the junk model design constructed from plasticine, and b) 3D printed artefact.

5. Discussion

5.1 Reflections on approach

Our approach of marrying Design Fiction with the Mantle of the Expert (MoE) technique was intended to support both holistic learning and stimulate creativity. Arguably, this approach meant that we were neither applying a pure version of MoE, nor focussing wholly on the processes and affordances of making Design Fictions. Under MoE, children usually take ownership of their own learning, yet in our project this was difficult due to the need to focus on the topic and guide children through a design process. Some of the potential of Design Fictions was also lost, as substantial learning time was devoted to gaining knowledge about bees and beekeeping as opposed to reflecting on and critiquing the possible worlds in which the children's designs resided. Indeed, it was striking that the keenest reflections came during teacher-led Philosophy for Children (P4C) sessions towards the start of the project, rather than at the end after the Design Fictions had been produced. For example, one teacher at School 2 enthusiastically recounted how children in her class thought they ought to petition government to conserve wild flowers and parks, but the teachers at School 1 were disappointed that they did not run the P4C sessions towards the end of the project, when the children had more knowledge of the subject.

The schools' curriculum and logistical requirements also had an impact on outcomes. Our work at School 2, spread over an entire half term, presented more opportunities for teachers to explore the topic in other settings, in a way that School 1 could not. It was gratifying to see children at School 2 work on bee theme parks in Maths, foraging flight paths in Geography, and adapting folk tales about bees in English and Drama. This led to the children in this school having much deeper knowledge of bees and beekeeping, and the environmental issues that they face. At School 1, the teachers felt that their shorter engagement meant that their initial knowledge of the topic was insufficient for addressing the task, but arguably this lack of subject scaffolding meant that their Design Fictions

were more imaginative than those produced at School 2, even if the worlds were less richly detailed. This raises interesting questions about the extent to which Design Fictions find a balance between being grounded in real world knowledge and pure imagination.

In terms of what the children thought of the project, two aspects were particularly popular: the opening field trip to Clumber Park, and undertaking 3D modelling on computers and seeing a 3D printer in action. These elements were the most novel in terms of breaking from the usual school routine and providing new experiences. While we should not perhaps read too much into their enjoyment of Clumber Park on a beautiful early summer's day, their clear enthusiasm for both physical and digital making was striking. One teacher remarked how well the children worked in "not only thinking about the bees' problems, but their own problems whilst they are making, whilst they are working together" (teacher from School 1). This thinking-through-making and collaborative working was also reflected in the reactions of the children, a mix of wonder, awe and pride, when they first viewed the 3D prints of their designs. This was evident despite the project team's concerns regarding the believability and fidelity of the 3D printed designs.

5.2 Materials and believability

Design fictions aim to render a fictional future world believable so that people can think about that world and its implications – how it might come into being and whether that would be a positive or negative development. The role of the design fiction prototypes is to unlock this future world. For this reason, design fiction prototypes are usually intended as convincing objects in our imagining of that world – they are usually made to the scale that they would be found 'in real life', and they are made from materials that make them believable as functioning objects. Examples include the iconic flip-top communicators in Star Trek, or the packaging and marketing materials for Polly, the smart, Internet Of Things kettle (Lindley et al., 2018). In our project, there was not the budget, time or materials to produce such realism. Moreover, the schools' desired learning outcomes were a factor. The request for 3D modelling and 3D printing within the project channelled the choices of materials and technology.

The iterative design process that led to the final 3D prints provided opportunities to work across different media: sketching multiple ideas, junk prototyping with different materials, and drawing and writing a newspaper article. These stages in the design process gave the children much more control in shaping the detail of their designs in comparison to the final 3D modelling. The teachers noted that the children "absolutely loved" working with the "different bits and bobs...like the plasticine" (teacher from School 2) in the junk modelling phase. They commented that the children do not usually have the opportunity to work with those kinds of materials and that they enjoyed the challenge of problem-solving as they transformed their 2D drawings into 3D representations.

Even if the design fictions themselves did not look physically believable as objects from the world, their very materiality, their 'thingness' (Ingold, 2013), allowed the children to suspend disbelief, and engage in imaginative, creative reflection. One of the aims of MoE is to frame the activities as professional work. While it was difficult for the children to use the 3D software to achieve a professional realism, the combination of the outputs from the project – the newspapers, filmed drama clips and collaboratively made junk models – overall produced a sense of quality and professionalism that elicited pride amongst the children, staff and parents across both schools.

The materials used in the final renderings may not have been believable within the future worlds, but their novelty to the children meant that they potentially gave credence to their assumed roles as experts; as designers that can produce 3D printed objects. The combination of design and drama complemented each other effectively in this project by reinforcing this sense of 'stepping out' from

their usual lived reality. This then enabled quite rapid and detailed learning about contemporary (and future) environmental issues.

5.3 Engaging with Environmental Issues

Honey bees are a keystone species, prodigious pollinators, with longstanding relationships with humans. They are commonly viewed as “good” insects, particularly in comparison to other insects such as wasps and spiders. As such, bees tend to elicit a great deal of enthusiasm and anecdotes. In School 2, where our work was spread over a whole half term, the children often spontaneously recounted stories about bees that they had saved in the playground or at home. Their wider learning was sufficiently detailed enough to be able to identify a surprisingly diverse range of UK plants and flowers popular with bees. Similarly, the comments captured during peer critique sessions revealed thoughtful questions and comments: ‘Wouldn’t the [bee] shower [idea] hurt [hurt] them?’ and ‘How will beetopia [bee dome idea] work in hot countries like Africa where there is not much rain?’, clearly demonstrating wider thinking and understanding beyond their own local context.

Whilst the project centred on honey bees, discussions throughout extended far beyond honey. Talks by beekeepers at the start of project highlighted the process and importance of pollination. A problem mapping and exploration session enabled children to think through the consequences of the loss of bees, from lack of clover and therefore grazing for cows, to the loss of their favourite fruits and even cotton. The design fictions themselves naturally relate to bees, but many of them consider wider environmental and social issues. For example, the children thought carefully about how to provide safe spaces for bees in an increasingly hostile environment, as well as the implications for society and our economies if bees and other pollinators were to become extinct. This depth of learning was reflected in an evaluation session held at the end of the project, where children recited an extensive array of bee facts, many of which they still retained four months later when we met them for our final engagement at York Explore Library. Moreover, some of these facts were mixed with empathy towards bees: “bees only have one sting, like we only have one heart”. In sum, as result of the project, the children developed a broad, nuanced understanding of bees and wider environmental challenges. This increase in empathy and wider learning skills supports the findings of other studies that have employed design approaches in schools (e.g. Carroll et al, 2010).

6. Conclusions

The project was well received by staff at both schools due to the high levels of student engagement and enthusiasm, as well as for the pride engendered in the production and exhibition of the final designs. At School 1, staff were impressed with the depth of knowledge and knowledge retention that resulted from the learner-centred, design-approach toward the topic.

Our project suggests that Design Fiction, used in conjunction with Mantle of the Expert, can be a useful approach for addressing complex issues, such as global environmental threats, because it provides opportunities for children to cast forward and imaginatively think through making, performing and discussing future settings, in ways that stimulate multiple senses and respond to the breadth of preferred learning styles in a class group.

It can be challenging for children to think about futures and there can be a tendency to fixate on the final artefact as a finished product, rather than a starting point for thinking about the future. Drama can enhance critical and reflective thinking about design fiction artefacts, which supplements creative thinking about future worlds.

Here we offer several considerations on the themes of planning and preparations, materials and technologies and structure within the curriculum, for researchers and educators wishing to pursue this approach.

1. School and teacher buy-in can influence the project progression so significant preparation and planning is needed to ensure everyone understands the aims and is aware of the unfolding stages in the process. The project needs sufficient resource in terms of space, staffing and, most importantly time. Teaching and learning styles, learning outcomes and curriculum demands need to be clarified at the outset to ensure a consistent approach, especially if the project is managed by multiple staff.
2. There are practical difficulties in realising truly diegetic prototypes, for example getting access to appropriate materials, having sufficient skill-levels to realise creations as envisioned, and class management challenges when children work with a plethora of materials. Material choices can significantly affect the believability of the fictions so we suggest that flexibility enables students to select the best materials to create a believable rendering of their design. Users should be aware of potential tensions because some material choices can expand imagination and creative potentials but present conflicts with curriculum objectives. In our case, it was desirable for students to learn to 3D print but it limited their creative outputs.
3. Design Fiction combined with performative elements can be used with little subject knowledge to create 'Freezes' (dramatic montage set around a design fiction) as a rapid process for generating questions about a new subject. However we suggest the Design Fiction method is most useful when integrated with other lead-in activities, in this case the garden visit and beekeeper talks, because extending the knowledge base gives children more content to work with in building their fictions and consolidates cross-curricular skill acquisition and development. Of the two structures used the longer, half-term structure was most effective because it allowed time, a) for consolidation of knowledge, b) for children, teachers and researcher to be responsive to materials; and c) as a buffer against technology failures.

Finally, we suggest the design fiction work could be further augmented and applied with follow-up activities that reintroduce external experts, for example beekeepers or environmental scientists. In this way the design fiction prototypes could be used to reflect back on the present, future choices and as a way to learn about new innovations that may be similar to the design fictions created by children.

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