Plastic chairs: Addressing the environmental emergency

Geoff Isaac[4]

Abstract

This article argues that product designers working with plastics can respond to our environmental emergency while satisfying their clients' commercial demands through a case study of plastic chairs. Through the lens of the 'waste hierarchy' this article demonstrates how contemporary designs can improve both environmental and commercial outcomes with innovative plastic products. Avoiding waste is the preferred strategy in the 'waste hierarchy'. To tackle the environmental crisis, we must reduce our reliance on fossil fuels, currently the main source of plastics. However, plastics can be made from organic material. Currently, less than 1% of plastic is made from renewable biomass sources, but advanced designers have already started to explore the potential of these biodegradable materials. In 2014, Karim Rashid developed the Siamese chair made from an eco-plastic derived from fast-regenerating Brazilian trees, completely avoiding fossil-based plastics. More common today are products that align to the second preferred option in the 'waste hierarchy' – to reduce or minimise waste. Decreasing the materials and energy required to produce a product perfectly aligns with capitalist management's traditional focus on maximising profit. I argue that product designers can influence the uptake of environmentally efficient product design, but this is not enough. Ultimately, we must create a movement that challenges the dominance of petrochemicals as the main source of plastics. I aim to demonstrate that new technologies can be adopted to reduce consumption of scarce resources, satisfying both environmental and economic goals.

Keywords

Plastic; Bioplastic; Biopolymers; Recycled Plastic; Karim Rashid; Siamese Chair; Yoris Laarman; Bone Chair

✉ Geoff Isaac: geoffisaac@hotmail.com

[4] Doctoral candidate, University of Technology Sydney

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Introduction

A chair made from fruit could hold a key to solving the environmental crisis caused by plastics. During 2019, the world produced at least 380 million tonnes of plastic, 190 times more than in 1950. If the demand for plastic continues to grow at its current rate of 4% a year, emissions from plastic production will increase from 4% to 15% of global emissions by 2050, making it virtually impossible to reach global emissions-reduction targets (Geyer et al. 2017). The immediate plastic crisis is not caused by products themselves but the inappropriate disposal of plastics, particularly packaging. Plastics get littered or dumped, finding their way into our oceans and waterways, fueling a consumer backlash that has resulted in bans on plastic bags and single use plastics and drives the increasing popularity of the media-driven war on plastics. The increasingly negative image for plastics generally is encouraging product designers to experiment with new materials and production techniques designed to reduce their environmental impact.

One of the first chairs to emerge using a bioplastic was the Siamese chair by Karim Rashid. Rashid is one of the most commercially successfully designers and claims to have over 4,000 designs in production and to have won over 300 awards (Rashid 2019).

Rashid is a proponent of democratic design, as promoted by Philipe Starck, and is interested in taking design to a wider audience. Rashid is particularly interested in using plastics to make his designs more accessible or democratic. Sustainability concerns were top of mind when he designed the Siamese chair for the Brazilian company *A Lot of Brazil*, which specialises in manufacturing furniture using renewable, locally sourced materials.

The Siamese chair (Figure 1) is made out of a new class of plastics made from biomass (organic matter). In this case the shell of the chair is made from completely renewable resources: bark from the Ipe Roxo (or pink trumpet tree), which regenerates in two years, combined with Acai, the use of which means the Siamese chair is, so far, the only chair to be made from a fruit. Usually 40% of the bark removed from the Ipe Roxo tree is discarded, as it is excessively moist, and this waste was used to develop the plastic for the chair (Koellner 2014). Rashid had to respond to the characteristics of this new material to develop the final form; the new plastic did not have sufficient structural strength to support a monobloc design (metal legs were added) and was not suitable to be used in thin moulds, so a bulky design was needed to provide the necessary strength.

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Figure 1. Siamese chair by Karim Rashid for *A Lot of Brazil*, 2014 (reproduced with permission from Karim Rashid).

I first encountered the Siamese chair in my international research focusing on plastic chairs from their initial development in the late 1930s. Chairs are often referred to as the quintessential design object – success can only be achieved by those designers with a strong understanding of the engineering challenges that need to be resolved in order to develop a successful design. Despite these challenges new chair designs are consistently revealed quickly after a new technology or material is developed. This decade has seen a flourish of activity with designers rushing to experiment with new materials and manufacturing techniques aimed at reducing the environmental impact of their work.

Pyramid of waste

It can be confusing to evaluate the effectiveness of these efforts but I have found it useful to rank designs by placing them on the waste hierarchy, a tool developed to illustrate the preferred (most sustainable) treatment of waste. The most desired outcome for any waste is to avoid creating it all together. When waste cannot be avoided the hierarchy shows us the next best option to consider – reduce, reuse, recycle, recovery, with disposal as the last resort.

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Most plastic chairs currently on the market are focused toward the bottom of the pyramid and are destined to end their days buried in landfill sites. While some chairs proudly claim they are made from materials that are fully recyclable – it is highly unlikely that they will actually be recycled, particularly given the recent developments impacting the global recycling industry.[5]

Further up the waste hierarchy there are innovative technologies and materials designed to reduce our dependence on petrochemicals. Many chairs are being manufactured using recycled (as opposed to recyclable) plastics. Also, many designers are experimenting with new technologies that can significantly reduce the quantity of material needed to make a product and even offer the possibility of eliminating packaging and transportation costs. Right at the top of the waste hierarchy a few designers are experimenting with materials which will potentially allow organic materials to take the place of traditional plastic – thereby avoiding the traditional plastics issue altogether. As we have seen, Rashid was among the first to experiment with bioplastics, or plastics made from biomass rather than petrochemicals.

More common today are products that align to the second preferred option in the waste hierarchy – to reduce or minimise waste. It is not surprising that there is activity in this space as decreasing the materials and energy required to produce a product perfectly aligns with organisational goals to maximise profit.

Joris Laarman's Bone chair (Figure 2) is the first chair to be co-designed with a computer and showcases how artificial intelligence has potential to optimise designs to minimise the use of scarce resources. The chair features a smooth-rounded seat and a high flat back, supported on three feet with legs formed like branches of a tree, immediately dividing to provide support where most is needed. The significance of this unique design was immediately recognised, with major museums in Europe and the United States of America buying examples, while the press, including the *New York Times*, hailed Dutch designer Joris Laarman, aged just 27, as the new Marc Newson (Giovannini 2017). The market was also quick to recognise this young talent with a Bone chair (from this limited edition of 12) changing hands at auction, in October 2019, for £237,500 (AUD$450,000) (Phillips 2019).

The design is therefore very niche (and efforts to mass produce a version of the chair failed) however, as highlighted by Ceschin in his PhD (Ceschin 2012) and Gaziulusoy in a paper summarising multi-level perspective (MLP) transition theory, "The niche innovation's level is particularly important as this is where the novelties initially emerge from the dynamics of the socio-technical regime, later putting pressure on it" (Gaziulusoy 2019). Niche incubation is seen is a key strategy to drive change across society.

[5] China's National Sword policy applied more rigorous contamination standards for plastic waste (0.5%), which most recycling processing facilities cannot currently reach, effectively stopping the export of plastic waste to China, with other Asian countries quickly following.

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Figure 2. Bone armchair, Joris Laarman Labs, 2007
(reproduced with permission from Joris Laarman Studio BV).

Laarman used software developed for the automobile industry using biomimicry principles to optimise the use of resources based on the study of trees and bones. Importantly, the process is subtractive rather than additive as with 3D printing.

The program removed material from the defined cube to optimise the use of resources, leaving thicker elements to bear loads and slimming down the remainder. The end product does have visual similarities with both trees and bones, unsurprising given both evolved using a similar process – reinforcing areas exposed to stress while eliminating unnecessary weight. Experimentation was used to optimise the plastic to gain the required finish, with white Carrara marble powder added to the polyurethane casting resin to achieve the attractive porcelain like finish.

The most important aspect of this design is that it is the first chair to be co-created with a computer. Previously, computers have been used purely as tools by designers to bring life to their creations but this work demonstrates that computers are now becoming powerful enough to participate in co-design – doing what they do best: performing complex calculations potentially facilitating a reduction in the consumption of materials, which deliver flow-on benefits through lower transportation costs.

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Relevance to product designers

As consumer products only account for 11% of all plastics used (Geyer et al. 2017), one might think efforts to reduce plastic use are better focused elsewhere, particularly on developing alternatives for packaging.[6] However, consumer products are highly visible and all packaging was designed by someone. Looking ahead, the use of traditional plastics will undoubtedly attract increasing criticism as the popularity of the war on plastics increases. It is almost certain that product designers, together with clients and manufacturers, will face increased scrutiny as they participate in the production of an endless array of consumer goods, many of which are designed to be quickly disposed of simply to make way for the next improved model. In addition, the use of bioplastics in consumer products can be seen as an important niche market that can support the adoption of these new materials by branching their use into new markets (in addition to packaging), helping to develop much needed economies of scale for their manufacturers (Geels 2005).

A review of the tools available to reduce our dependence on fossil-fuel based plastics highlights the importance of the role of product designers. There are four groups of levers (or tools) that could be used to reduce demand for plastics (Zheng Suh 2019). Firstly, we can attempt to manage demand. Price is the main tool here – oil price increases from wars in the Middle East are useful to stem demand – but they are usually short-lived. A carbon tax would be a better long-term fix, but unlikely to occur – at least in Australia. It is encouraging to see Andrew Forrest has launched a global initiative to get major manufactures to sign up for a voluntary levy on fossil-fuel plastics (Cox 2019). Although, with thousands (or even tens of thousands) of small manufacturers eager to expand production, it is difficult to imagine how this initiative can succeed.[7]

Secondly, switching to renewable energy to manufacture plastic would dramatically reduce the greenhouse gas impact from the industry. Again, this is a long-term solution requiring political will and serious investment (and, ironically, many plastic components). Thirdly, we could increase our recycling rates, making the plastics industry more circular – but given only 9% of all the plastic ever made has been recycled (Geyer et al. 2017.), and China (and other Asian countries) have stopped taking everyone else's waste, the reality is it will be years before Western countries can obtain planning permission and develop the infrastructure required to have a significant impact on the proportion recycled. In the short-term, designers have an important role to play here. By considering what will happen at the end of a product's life, designs can be developed for ease of disassembly, allowing materials to be easily

[6] For example, the recent European Union directive on the reduction of the impact of certain plastic products on the environment.

[7] Dematerialisation is also relevant in reducing demand – as we have seen with CDs and DVDs, the very need for these plastic products has been replaced by advances in digital technology, reducing or completely eliminating demand for plastic discs. In Australia, plastic bank notes are quickly disappearing as the popularity of cashless payment methods increases.

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separated to facilitate economically viable recycling. Finally, we can investigate alternative raw materials to replace petroleum to create polymers. Although this bioplastic market is embryonic, only accounting for less than 1% of all the plastic produced this year, there are some exciting recent developments. As already discussed, product designers have already started exploring this fourth option, the main option that designers have the power to influence if they are interested in improving the environmental footprint of their products. I should emphasise here the role of other actors, notably clients and manufacturers, as product designers often have very little agency in the final selection of materials. However, making the information needed for designers to familiarise themselves with the properties of these new alternative materials will better place them to guide projects toward more sustainable outcomes.

Designers stepping into the bioplastic market are met with a bewildering range of brand names, jargon, acronyms and marketing claims that make it difficult to evaluate the environmental credentials of these new materials. For example, the bioplastic used to develop the Siamese chair is made from a renewable biomass resource that is claimed to be completely biodegradable – although no information has been published on the conditions needed for this plastic to degrade or how long it would take. More generally, many confusing claims are made about the biodegradability of bioplastics (Lackner 2015; UK Government 2019). Often what is meant is that the product will degrade to carbon, water and biomass but only under certain heat and moisture conditions – usually those prevalent at industrial composting facilities, which are rare (Plastics Industry Association, 2019). Developments in the bioplastic industry have been driven by the need to develop alternatives to plastic packaging, hence the focus on degradability. However, biodegradability is unlikely to be an important consideration for product designers. If they are concerned with the impact on the environment designers probably want their creations to last decades. It is probably more appropriate to focus on the recyclability of the new materials available which contributes to the circular economy. While many of these materials are theoretically recyclable, like all plastics, bioplastics can only be recycled if sorted and treated with the same material. Sorting is challenging as all bioplastics are currently labelled '7', a catch-all 'other' category in the Resin Identification Code scale, which also includes various petroleum-based plastics. Together with a lack of sorting infrastructure this means bioplastics are highly unlikely to be recycled in the short term.

Navigating the jargon

A key to cutting through the jargon is to investigate what the bioplastic is made from. The term 'bioplastics' has been abused and often applied to plastics containing as little as 20% biomass – the remainder, up to 80%, can be traditional petrochemicals. The term bioplastic does not offer any assurance that the substance is biodegradable. Often referred to as drop-in polymers, these hybridised plastics are popular with manufacturers as they can be dropped in to replace fossil-based ingredients without the need to alter existing machines or processes. These compounds are often environmental disasters and will not biodegrade.

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As many bioplastics are new, product designers and manufacturers need to familiarise themselves with the properties of the material and satisfy themselves they are fit for purpose. Of special concern might be the melting point, heat and impact resistance of some of these new materials (which are often lower than conventional plastics). Also worth highlighting is the fact that some bioplastics are significantly denser than traditional plastics, by about 20% (Lackner 2015), which not only affects the final product but can have significant environmental impacts, from the additional energy needed for transportation.

Beyond this basic evaluation of the new materials' suitability to a specific task, environmentally conscious designers and manufacturers need to consider a full lifecycle assessment – where did the material come from and how will it end its life? Even the briefest consideration of these issues outlines just how complex this task can become. If bioplastics are produced from agricultural crops they are immediately competing for land use, which is already in short supply, let alone with the projected increase in population expected by the end of this century. How the land was cleared, how the crops were fertilised, farmed and harvested and what chemicals are used in the manufacturing process, potentially causing ecotoxicity, are also important considerations.

Although many, including Tony Fry (Fry 2009) and those working in Transitional Design (Tonkinwise et al. 2015), would argue that this should be the concern of all product designers, for example:

> *To continue with business as usual with a few token gestures toward 'sustainability' is frankly a disposition of collective stupidity. No matter how hard or painful, a process of substantial affirmative change is essential. (Fry, 2017)*

The reality is that, faced with tight deadlines and heavy workloads, most product designers do not have the time needed to grapple with these issues. In any event, manufacturers and clients often have firm views on what materials should be used and are determined to continue to use manufacturing processes they have invested both time and money to perfect.

> *While there have been many calls for, 'design-led societal change, few have articulated how to undertake and lead/catalyze such change, nor have they identified the areas of knowledge and investigation required to do so.' (Tonkinwise et al. 2016, p3)*

I propose to examine the tools being developed in this new area of academic study and evaluate their relevance to product designers seeking to drive change within the systems they operate. As part of my research I am talking to designers and manufacturers about these issues and the barriers to working with new materials and technologies. The interviews, so far, definitely highlight some of the misunderstandings around the materials and their end-of-life prospects. I hope to expand my interview base to include a wide range of designers and to further explore these barriers to adoption.

Conclusion

In the short term, it is most likely we will see more new plastic chair designs that will be ranked toward the centre of the waste pyramid. There are great advances in additive manufacturing – with 3D printing offering the added benefits of potentially reducing transportation and packaging costs – allowing products to be created at, or near, their point of consumption. Joris Laarman has already made available a Puzzle chair that can be downloaded and printed on a standard domestic 3D printer – although you do need a spare 240 hours to print it! We are also beginning to see new technologies explored to reduce the amount of material needed to create a product. More commonly, designers are experimenting with recycled plastics – making chairs from recovered ocean plastics (Snøhetta's S-1500 chair, Figure 3), children's toys (Vanessa Yuan & Joris Vanbriel's Chair Charlie, Figure 4) or even household plastic waste (Thomas Pedersen's Falk chair, Figure 5).

Figure 3. S-1500 chair by Snøhetta, for Nordic Comfort Products, 2019 (image credit Bjørnar Øvrebø, reproduced with permission from Snøhetta).

All these efforts are welcome if we are to make an impact on our consumption of plastic. In the first 10 years of this century we created more plastic than in the entire twentieth century. As pressure to focus on the climate emergency intensifies it is likely that product designers will be held increasingly accountable for their creations and encouraged to embrace Herbert Simon's definition of design as 'devising a course of action aimed at changing existing situations into preferred ones' (Simon 1996).

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Figure 4. Chair Charlie by Vanessa Yuan & Joris Vanbriel for ecoBirdy, 2018 (image credit Arne Jennard, reproduced with permission from ecoBirdy).

Figure 5. Falk chair by Thomas Pedersen for Houe, 2019 (reproduced with permission from Thomas Pedersen).

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This article outlines a range of emerging technologies and materials, already available to allow designers to continue to enjoy the benefits and economies of working with plastics while participating in the movement to replace fossil fuels as their main ingredient. There is a need to support designers looking to improve the environmental impact of the products they design and to investigate if plastic made from fruit, or other organic material, really can be part of the solution to our environmental emergency.

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About the author

Geoff Isaac is a PhD candidate at the University of Technology Sydney. His doctoral project on the history of the plastic chair focuses on how designers are responding to the environmental crisis by introducing recycled plastics or bioplastics and experimenting with new manufacturing techniques to minimise the use of materials and energy. Geoff's interest in design grew from his appreciation of the work of Australian mid-century designer Grant Featherston. His monograph *Featherston* was published by Thames & Hudson in 2017.

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