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Embrace the change: Framing Demonstrators as an Alternative to the Mass Production Norm in Industrial Design Education

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It is believed that industrial design was born in a big industrial bang as a tool sharpened for mass production. As an alternative to craft, industrial design practices were aimed at utter generalization and efficiency to minimize the price of a single piece. But over time, technological progress and changes in mindset made this approach obsolete. Despite the growing awareness that there is a need for a new design mode, only alternatives can be found in bespoke professional equipment and prototyping areas. Meanwhile, an emerging topic called 'demonstrators' appears in the field of design. This paper explores this area through several examples and argues that demonstrators can be framed as a design mode that design education should refer to, due to their advantages over mass production. Demonstrators grasp the current technological state and represent it as a single-piece object, not only enhancing the manifestation of new ideas and bringing stakeholders together but also enhancing portfolio for industry. Four inherent characteristics of demonstrators are presented, namely: 1) they convey a message; 2) they are designed for exposure; 3) they snapshot the present, and 4) they are finished products. Together they establish a fluid definition of the notion of demonstrator and set directions for further research. The first steps towards an analysis of the possible solution space of demonstrators highlight three defining axes: form, context, and time.

Keywords: demonstrator; job production; alternative design mode; fluid definition; IASDR

1 Introduction

Industrial design emerged as a response to the rapid growth in the production of manufactured goods during the Industrial Revolution. This is why its evolution followed the development of the industry. First, designers helped harness and promote new technologies by bringing hundreds of new products to the public. They refined the manufacturing process to reduce the costs and created new markets with new luxury goods. However, with the saturation of these markets prices to previously unattainable goods fell and the profit received from each piece also decreased. It forced manufacturers to produce a large number of goods to deliver to large markets in order to sustain (Robinson, 1963). Consequently, designers shifted towards stimulating sales by designing products that looked more appealing (Heskett, 2016).

Today's discourse around consumerism highlights negative aspects of the prevalence of the mass production design paradigm, such as low quality of products, planned obsolescence, and artificial demand. In addition, industrial design contributes to it with warehouse, logistics, and disposal costs. However, this problem did not appear yesterday. At the end of the 19th century, William Morris noticed a vicious circle of mass production and criticized the process of making machines to produce an enormous number of useless things to sell to the public, which does not want them (Morris, 2021).

The designer's role has changed several more times since then, shifting its focus from technology to context (King and Chang, 2016), and from economic imperatives (Walsh and Roy, 1985) towards adding meaning and human values (Krippendorff, 1989; Papanek, 2019). However, schools still teach Industrial designers to design products to be ready for manufacturing in large quantities. For nearly a century, technology was not yet advanced enough to question the relationship between cost and quantity in manufacturing (Mason, Stone and Perloff, 2008). As a result, mass production has become the norm in our time and led to the fact that education for industrial designers is based mainly on this norm. It means that no matter how advanced and complex their role may be, they are limited to a single design mode.

The industrialization has irreversibly changed the world. It did not happen in one day, however, even the period of around two centuries was barely enough for people to adapt. Initially, changes were subtle and considered as relief of hard work: while an untrained worker could make only one pin a day, with help of machinery this number might be increased tenfold (Smith, 1976). By the time the number went into millions, nothing remained of the usual life: people moved from villages to cities; blue collars replaced farmers and were eventually replaced by white collars; internet connected the world and then brought the feeling of disconnection stronger than ever. Over the past 150 years, humanity has experienced three Industrial Revolutions and is in the process of a fourth. Not surprising that people struggle to cope with such an avalanche of changes. Alvin Toffler calls this phenomenon "future shock" (Toffler, 1987).

Changes affect not only consumer demand, the nature of products, the economics of production, and the economics of the supply chain (Hagel *et al.*, 2015). It means that a fundamental shift in manufacturing is about to happen. As in the case of the first Industrial Revolution, it will not happen in one day. Nonetheless, the shift is inevitable, meaning, that it might be a good time to reconsider well-established practices under the new conditions. As Heskett claims, "We cannot turn the clock back. We can, however, be clear about our philosophy and values and seek opportunities in the process of change to give them new directions, new forms and expression."

An emerging topic called *demonstrators* might become an alternative. According to the Merriam-Webster dictionary, a demonstrator is *a product used to demonstrate performance or merits to prospective buyers*. In the field of industrial design, the understanding of a demonstrator is more versatile. It is a concept that combines design, art, and engineering and can be used as a boundary object, an embodiment of a future product, or an interactive manifestation. Due to its innovative nature, demonstrators are bespoke products that are built in one exemplar, rarely in several copies.

Design object is a result of balancing answers to questions "why?", "what?" and "how?" They define a challenge that needs to be solved, a solution itself, and methods to use to get the best solution within the set conditions respectively. However, in terms of demonstrators, there is no yet theoretical approach to studying these questions. First, little is known about how to separate it from other outcomes of industrial design. Second, the mechanism through which the demonstrator interacts with stakeholders is not yet well described. Finally, there is a knowledge gap in understanding what influences the final design.

This paper presents a research agenda by characterizing common attributes of demonstrators based on studying three selected cases, by proposing a framework for studying the mechanism by which demonstrators bring stakeholders together, and introducing a tentative model of a solution space for further analysis.

2 Alternatives to mass production

What are the alternatives to mass production? First, there is specialized equipment designed for a particular industry sector such as medical devices, laboratory equipment, or tailor-made machinery. It usually demands from designer to find a better (cheaper, faster, or more convenient) way how to perform certain existing practices (Tamsin and Bach, 2014). Their development process often involves close collaboration with engineers while designers are more responsible for the interface part. Examples are, as follows, a special purpose machine for an equipment end-user, a special purpose tool for an original equipment manufacturer, or the design of an automated assembly line *(Equipment Design Project Profiles | Design Group)*. However, the amount of such equipment depends on demand: as soon as there is a need and technical capability, the production process will be converted according to mass production needs.

Another kind of small batches production is limited edition product design, e.g. furniture or ceramics. In this case, the number of items is artificially limited to make them rare and therefore desired. Unlike mass-produced goods, they can look quite unorthodox or made of rare materials since low-batch production allows experimenting. High price often reflects the uniqueness of the objects but does not guarantee success on the market. On the other hand, a collection of such products can ignite a cycle of fashion as happened with the first Memphis collection in 1981. Karl Lagerfeld was so impressed by their design that he furnished his entire apartment with the provocative chairs, lamps, and tables. However, he sold his collection 10 years later, once again proved the volatility of fashion (Radice, 1991).

Finally, there are prototypes as a representation of an intermediate result or a tryout of a proposed concept (Lim, Stolterman and Tenenberg, 2008). According to Michael Schrage, they are hypotheses, marketplaces, and playgrounds (Schrage, 2013). However, prototypes are either never meant to be an outcome of a project or aim to be mass-produced one day. Catharine Rossi makes an example of Gio Ponti's Superleggera chair when the advanced materials used to ensure the incredible lightness of it demanded manual production. Paradoxically, after ten years of prototyping and reaching the desired result, designers realized that it was impossible to reproduce it for the mass market (Rossi, 2013).

Demonstrators significantly differ from any of the described categories. They are more provocative, engaging and do not imply their users to be specialized professionals. They are not intended to be marketed but are finished products designed to solve a certain problem. Meaning, they can make money, thereby paying off their production. The phenomenon of demonstrators, however, is not new. Heskett describes the Great Exhibition in 1851 as "overwhelming decoration … (that) hardly represents the state of manufacture". He continues though, that products shown there and designed to attract customers, promoted "the relationship between art and industry … gave new impetus in Britain to measures of reform in design practice, theory and education". Eiffel Tower can also be considered as one: it was designed to praise the excellence of French engineers at the world's fair; it was a finished ready-to-use project, that even paid off during the exhibition and it was built of innovative at that time metal trusses. In turn, designers of the Superleggera chair built a demonstrator, when they hung one of their chairs on a stand to show how light it is.

Nevertheless, none of the aforementioned alternatives became a new norm. We argue that demonstrators are a promising category to research since they combine innovations with the fast design cycle reducing costs of production and further utilization. Together with the ability to connect stakeholders and address complex issues, it makes demonstrators a prominent candidate to meet the requests of the current Industrial Revolution.

We will start the analysis by describing three selected exemplars. The first two were developed by the co-authors, while the third is a well-documented demonstrator that made a global impact on the design community.

2.1 Flanders Make Race track

Flanders Make, a strategic research center for the manufacturing industry, developed a new algorithm of optimization. They wanted to show the advantages of it to potential clients at their annual symposium. Usually, engineers have a physical setup that speaks for itself, but in this case, there was nothing to display except numbers. Thus, the main challenge was to present the algorithm and its possible applications in an accessible way to people who has no background in mathematics or knowledge of programming. Therefore, it was decided to go for a physical object to attract visitors' attention and encourage them to learn more about the technology.

Figure 1. The process of adjusting the projection (left), the finished stand (middle) and the projected animation (right)

The result of the work of a design team was a stand with a relief representation of a racetrack. A video was mapped on its surface with a projector hidden in a small cabinet in front of it. This format supposes a presence of a guide verbally explaining the nuances of the algorithm (Sviridova *et al.*, 2021), but even without the projection, the object looks attractive.

2.2 MX3D Bicycle

While working on a project of an innovative 3d-printed metal bridge, MX3D, a studio specialized in 3d metal printing, decided to test the performance of 3d-printed metal joints as well as determining the life cycle analysis of this type of digital manufacturing (Bekker and Verlinden, 2018). Instead of printing several examples of such joints, a fully 3d-printed metal bicycle was developed. Its unconventional structure looked appealing enough to be highlighted in magazines and online media, which drove public attention to the technology and its application, while also testing its durability in an entertaining and engaging way.

Figure 2. The 3d-printed bicycle (left) and the joints close-up (right)

2.3 Mine Kafon

Massoud and Mahmud Hassani, the initiators of this project, grew up in a little town in Afghanistan. During several wars that happened on the territory of this country, its sandy areas were mined. Although the troops were withdrawn, nobody took the responsibility to remove the mines, preferring to just mark dangerous zones and leave all the explosives behind. It costs $1200 to clear one mine, which explains why nobody is doing it. Therefore, a giant wind-powered device with a total cost of material of €40, which can roll across desert detonating mines by stepping on them with its legs, looked like a decent alternative (*History | Mine Kafon*).

This project was first presented as a prototype, which, being refined and produced in series, would be released on dangerous territories and little by little clear all the mines. However, after a very positive reception in museums and exhibitions and the great success of their Kickstarter campaign, the designers decided to develop a drone as a mass production solution, leaving the Mine Kafon Ball as a tool to raise awareness of the problem.

As seen in this small collection, demonstrators can take any shape. They can be digital or analog, explanatory or provocative and they can address concrete or abstract issues. They might be a result of a work of a design team for a client, a byproduct of another design process, or a personal initiative. Such an abundance of possible options makes it difficult to distinguish demonstrators from other outcomes of design. They can be confused with prototypes and even art objects. Therefore, first, we will dwell on the issue of demarcation.

Figure 3. The assembly process (left) and the finished object (right)

3 Framing demonstrators

The diversity of demonstrators looks vast, but several similarities can be found after the analysis of the described exemplars. What differentiates them from prototypes/art objects is that they all feature four characteristics:

Demonstrators convey a message

Many factors affect the appearance of a design object. Among them are ergonomics, ease of manufacture and assembly, optimization of the number of materials used, and many more. Demonstrators are built to convey the message so their effectiveness as media is very important. The message encoded can be the full spectrum from a provocative manifestation to an informative representation.

Demonstrators are designed for exposure

Prototypes are designed to filter ideas and explore the possible solution space. Mass-produced objects usually fill a particular market niche or satisfy certain customer needs. Demonstrators are meant to help stakeholders communicate. They are often designed for exhibitions, where customers can interact with them, or get a big highlight in media, drawing attention to a certain problem or promoting new technology.

Demonstrators snapshot the present

Demonstrators might use futuristic or unorthodox technology but in a way of showing how they can be implemented today. The outcome is a product (in its very broad meaning) that is ready to use right now, unlike prototypes that represent how the product should look in the future.

Demonstrators are finished products

Bringing a finished product to market can take a long time, considerable part of which is spent developing and preparing the production line. Due to their shorter development cycle, demonstrators can start returning investments much faster, while at the same time collecting data for the possible future improvements. In other words, while prototypes usually represent a certain stage of a process, demonstrators are ready-to-use products and if there is a need of a modification of a design, the next version might look like an entirely different object due to possible changes in technology or in the way it interacts with a user.

A comparison of these characteristics is presented in Table 1. The diversity of how they intersect in each project forms a solution space of demonstrators, a set of design representations that ensure the effective solution of the problem.

Table 1. Four characteristics of demonstrators design on the example of three described projects

Four principles of demonstrators design	FM Race Track	MX3D Bicycle	Mine Kafon
Design to convey a message	A metaphor of a racetrack was used to explain how their new optimization algorithm excels the current method. This metaphor also represents the application of the algorithm in the automotive industry.	There was no need to make a bicycle to test the durability of 3d-printed joints, but it was an elegant way to demonstrate the availability and reliability of the technology	A metaphor of a tumbleweed was chosen to convey a feeling of deserted land, abandoned by its inhabitants. After it was mined during the war, nobody could survive there except rare plants rolled around by the force of the wind.
Design for exposure	The demonstrator was built to be displayed at their annual symposium; hence, the entertaining projected animation and three-dimensional design, which is attractive even when the projector is turned off.	The project was in the spotlight in magazines and online media, bringing together industry and customers.	The design was optimized to fulfill the usual norms of design for mass production, but apart from that, it looks colossal. A giant tumbleweed worked primarily as an art object and only then as an industrial product.
Design to snapshot the present	The main goal of the design was to demonstrate the algorithm the client has already developed with technologies that are available right now to transfer its innovativeness yet availability.	A technology of 3d metal printing is apparently too futuristic to be used in daily life. It is developed well enough to be used in architecture but it is not hardly welcomed by city administrations. Such a familiar object as a bicycle helped bridge the gap between policymakers and technology.	The project was designed so that the inhabitants of the mined regions can easily reproduce it in their current conditions.
Design of a finished product	The demonstrator represents the current state of the algorithm and is ready to present it to customers. After the presentation it is planned to exhibited in the client's office.	When the performance of metal joints is tested, it can be sold to a museum or just keep being used as a regular bicycle.	Despite proven ineffectiveness, the Mine Kafon Ball is ready to roll around the desert and clear mines. An improvement of efficacy led to a radical change in design.

As it can be seen in the examples, the design for demonstrators intertwines multiple disciplines, making it difficult to generalize. Therefore, a fuzzy definition established by a set of characteristics might be sufficient for the next stage of the analysis In the absence of a formal definition of a demonstrator, these characteristics can be used to identify whether a design object can be categorized as one. A notion of a fluid definition will be introduced in the next section.

4 Theoretical underpinning

4.1 Studying demonstrators as boundary objects

Existing studies view the purpose of demonstrators as translating science from laboratory to the market, convincing potential customers of the feasibility of the technology, and visualizing potential future applications (Moultrie, 2015). In any case, demonstrators are described as mediators designed to provide shared understanding among stakeholders.

Artifacts used as mediators between actors are known in the literature as 'boundary objects' that are developed and used through interaction (Henderson, 1991). This mechanism is explained by an adapted framework of the communication process (Wang and Xia, 2019). It shows an interaction between a client as a sender, a customer as a receiver, and a designer as a transmitter of a message encoded in a medium, which in this case, is the demonstrator.

A similar communication mechanism is found in the advertisement, when three aspects of successful message transportation, including cognitive attention, mental imagery, and emotional involvement should be addressed (Rodgers and Thorson, 2019). Another underpinning perspective is found in the perception of art, e.g. in establishing personal rapport between the artwork and its audience (Pepperell, 2012). People appreciate the act of interpreting ambiguous messages, even though they usually enjoy finding the familiar (Muth, Hesslinger and Carbon, 2015). Striking the right balance between ambiguity and familiarity is a challenge. Furthermore, human reasoning, experience, and everyday language are impacted longer if we embody the message in inanimate materials such as a physical setup like a demonstrator (Law, 2010).

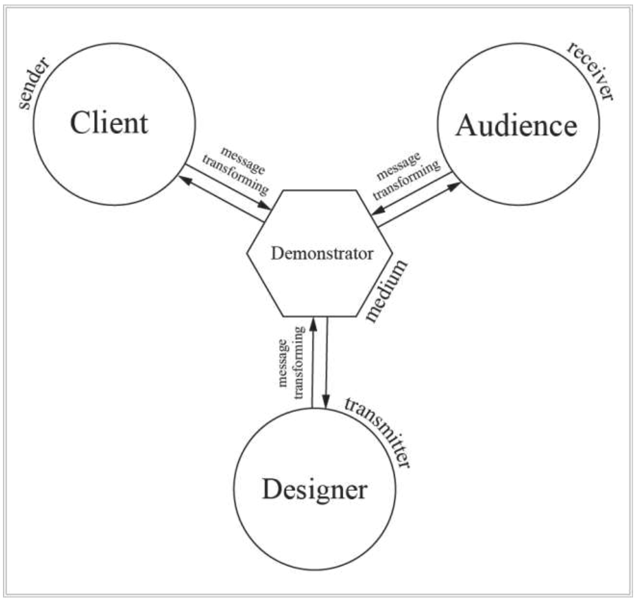

Figure 4. Basic framework of communication process between stakeholders.

A communication framework depicted in Figure 4 shows that the roles of a sender, a receiver, and a transmitter are equally important. In terms of design, it means that a balance between the goals and needs of each party involved affects the demonstrator's appearance. Focus on one of the parts defines the answer to the question “why?” for example by making the medium more or less ambiguous and choosing emotions or cognitive functions of a receiver to address.

4.2 A tentative model of a demonstrators’ solution space

The answer to the question “what?” defines a set of possible solutions for the defined “why?” It contains all the possible forms in all the possible contexts. The answer to the question “how?” defines all the variety of methods and tools that designers can use to make a demonstrator that conveys a message in the most effective way. Due to the high versatility of options, there is a need for a framework that helps categorize and analyze them. It is tempting to start studying demonstrators by comparing them with prototypes, engineering, or art objects. However, these fields are too fuzzy and overlapping. An attempt to untangle them arises a dilemma of “rigor vs. relevance”, which inevitably leads to getting into “swampy lowlands” of problems with methods of inquiry and interpreting the results (Schön, 1984).

Historically, industrial design is based on dichotomies (Glazychev, 2006), some of which contradict each other. It is both an activity and an object, which negotiates form and function and balances between needs of business and value for customers. For a long time, designers have been forced to choose one side: theory or practice, art or science, business or academia. Because of this, design seems to be quite resilient to chaos and uses such instability to forge new meanings. However, the use of the same methods in design research as in natural sciences significantly reduces the possible theorizing outcome. Science demands to start with setting clear definitions as fundament for a future research building, In the case of design, it works the other way around and leads to situated knowledge. It means that results are often dependent on the time and context of the conducted research and cannot be generalized.

Redström proposes a concept of ‘an unstable definition’ and argues that its fluidity helps to address the whole spectrum of possible characteristics (2017). Such definitions are very general but become concrete if needed. Based on this idea, the axes of demonstrators’ multidimensional universe are set as such: form, context, and time. Although he defines ‘form’ in his book, it is worth making it slightly more particular by applying it to the field of demonstrators. Consequently, ‘form’ can be defined as a solution to the problem, which emerges in the associated acts of perception. ‘Context’ means a frame that is set by interrelated conditions and defines the problem (Alexander, 1973). Finally, ‘time’ sets the position of the solution and/or the solver between present and future. In Figure 5, each axis represents possible values within a spectrum of the definition’s space. Thus, context specifies a domain between general and particular, form lies within explanatory and provocative and time sets the areas from present to future.

We propose a two-dimensional subspace of demonstrators is created by making the axes more specific, which makes it easier to map the demonstrators’ manifold. Now, when it is possible to identify a demonstrator as a design product with a certain combination of characteristics, the next step will be collecting many exemplars of demonstrators, map them in the given space and analyze the received data.

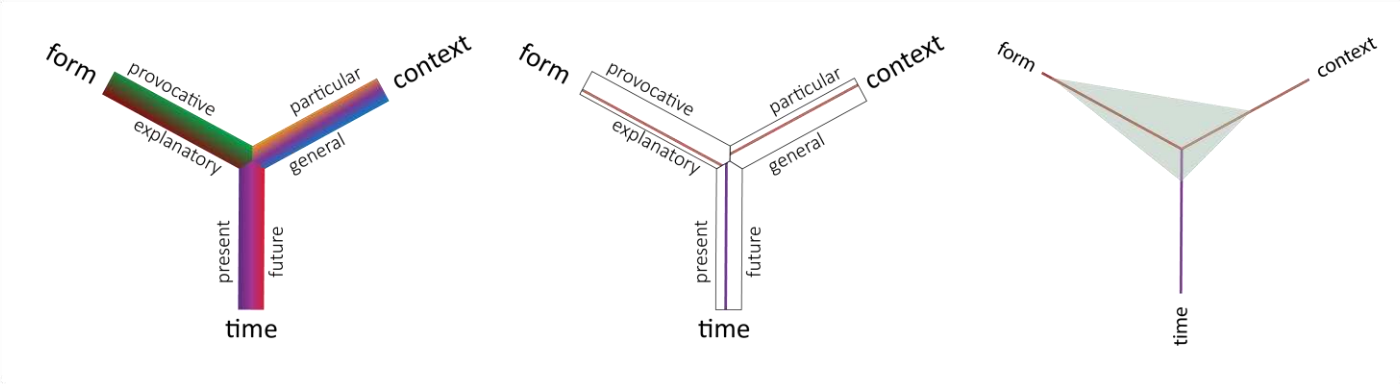

Figure 5. Solution space of demonstrators set by spectrums of form, context, and time (left) and its application on the example of the FM Race track (center and right).

For instance, the FM racetrack project was set within a space of relatively particular context: a symposium organized by Flanders Make themselves to present their projects to their potential clients. It means that in order to present their algorithm as one that is possible to be implemented to their clients' businesses in the nearest future (time axis) it needs to be explained as clearly as possible, leaving little space for ambiguity (form axis). Since objects in multidimensional space cannot be correctly compared with each other, they have to be projected into three-dimensional space. When each of the definitions is concrete, it is possible to evaluate them on each axis. Thus, an explanatory form now can be rated from digital to physical, context then goes for the number of constraints considered in the design and time shows how well the idea of a possible instant implementation is expressed.

A tentative solution space is proposed to look for the criteria for analyzing demonstrators. It is not yet clear how to compare projects designed for the opposite ends of spectra, however, collecting more exemplars might form a dataset that is possible to analyze.

5 Discussion and conclusions

Industrial design as a highly flexible and innovative field is inherently tolerant of change. Yet, due to its close connection with the inert industry of mass production, a possible change in design mode could be perceived as a disruption. With the advancement of technology and the increasing complexity of design problems, a focus on job production might unlock new opportunities for industrial design, closing chasms between product makers, product sellers, and product users. Due to their nature, demonstrators might fit in this process very well as media. Therefore, it might be of interest to study the phenomenon and methods of their development with a possibility to further use the knowledge gained to rethink the design education program.

This paper questions design for mass production as the main approach industrial design uses for many years. An emerging field of design activity called demonstrators is highlighted as an alternative mode and portrayed by several exemplars. Four characteristics of a demonstrator, namely: 1) they convey a message; 2) they are designed for exposure; 3) they reflect the present, and 4) they are finished products are highlighted and described. A tentative model of demonstrators' solution space and its application to the described exemplars is proposed. Form, context, and time are defined as three main aspects for further exploration of demonstrators as a phenomenon and their place in design practice and education. Together with an adapted framework of the communication process, each of these steps forms a direction for further research.

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References

Alexander, C. (1973) *Notes on Synthesis of Form*, *Vasa*.

Anon (no date a) *Equipment Design Project Profiles | Design Group*. Available at: https://www.bwdesigngroup.com/our-solutions/equipment-design-solutions/project-profiles (Accessed: 9 May 2021).

Anon (no date b) *History – Mine Kafon*. Available at: https://minekafon.org/index.php/history/ (Accessed: 10 June 2021).

Bekker, A. C. M. and Verlinden, J. C. (2018) 'Life cycle assessment of wire + arc additive manufacturing compared to green sand casting and CNC milling in stainless steel', *Journal of Cleaner Production*, 177, pp. 438–447. doi: 10.1016/J.JCLEPRO.2017.12.148.

Glazychev, V. (2006) *Design as it is*. Evropa.

Hagel, J. *et al.* (2015) *The future of manufacturing | Deloitte Insights*. Available at: https://www2.deloitte.com/us/en/insights/industry/manufacturing/future-of-manufacturing-industry.html (Accessed: 9 May 2021).

Henderson, K. (1991) 'Flexible Sketches and Inflexible Data Bases: Visual Communication, Conscription Devices, and Boundary Objects in Design Engineering', *Science, Technology, & Human Values*, 16(4), pp. 448–473. doi: 10.1177/016224399101600402.

Heskett, J. (2016) 'Commerce or Culture: Industrialization and Design', in Dilnot, Cl. (ed.) *A John Heskett Reader*. Bloomsbury, pp. 24–41.

King, S. and Chang, K. (2016) *Understanding Industrial Design [Book]*. O'Reilly Media, Inc. Available at: https://www.oreilly.com/library/view/understanding-industrial-design/9781491920381/.

Krippendorff, K. (1989) *On the Essential Contexts of Artifacts or on the Proposition That 'Design Is Making Sense (Of Things)'*, *Source: Design Issues*. Available at: https://about.jstor.org/terms (Accessed: 26 April 2021).

Law, J. (2010) 'Notes on the Theory of the Actor Network : Ordering, Strategy and Heterogeneity', *Science Studies*, (1), pp. 1–10. doi: 10.1007/BF01059830.

Lim, Y. K., Stolterman, E. and Tenenberg, J. (2008) 'The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas', *ACM Transactions on Computer-Human Interaction*, 15(2). doi: 10.1145/1375761.1375762.

Mason, C., Stone, L. and Perloff, J. M. (2008) *Study guide for Microeconomics: theory & applications with calculus*. Pearson.

Morris, W. (2021) 'Art and Socialism', in *Democratic Socialism in Britain*, pp. 1a-58a. doi: 10.4324/9781003192121-2.

Moultrie, J. (2015) 'Understanding and classifying the role of design demonstrators in scientific exploration', *Technovation*, 43–44, pp. 1–16. doi: 10.1016/j.technovation.2015.05.002.

Muth, C., Hesslinger, V. M. and Carbon, C. C. (2015) 'The appeal of challenge in the perception of art: How ambiguity, solvability of ambiguity, and the opportunity for insight affect appreciation', *Psychology of Aesthetics, Creativity, and the Arts*, 9(3), pp. 206–216. doi: 10.1037/a0038814.

Papanek, V. (2019) *Design for the Real World*. 3rd edn. Thames & Hudson.

Pepperell, R. (2012) 'The perception of art and the science of perception', *Human Vision and Electronic Imaging XVII*, 8291(February 2012), p. 829113. doi: 10.1117/12.914774.

Radice, B. (1991) *Memphis: La Collection of Karl Lagerfeld*. Sotheby's Monaco S.A.

Redström, J. (2017) *Making Design Theory*. The MIT Press. doi: 10.7551/mitpress/11160.001.0001.

Robinson, E. (1963) 'Eighteenth-CentuT Commerce and Fashion: Matthew Boulton's Marketing Techniques', *The Economic History Review*, XVI(1), pp. 39–60.

Rodgers, S. and Thorson, E. (2019) *Advertising Theory*, *Advertising Theory: Second Edition*. Edited by S. Rodgers and E. Thorson. Second edition. | Abingdon, Oxon ; New York, NY : Routledge, 2019. | Series: Routledge communication series |: Routledge. doi: 10.4324/9781351208314.

Rossi, C. (2013) ‘From Mari to Memphis: The Role of Prototypes in Italian Radical and Postmodern Design’, in Valentine, L. (ed.) *Prototype: Design and Craft in the 21st Century*. Bloomsbury, pp. 29–44.

Schön, D. (1984) *The Reflective Practitioner: How Professionals Think In Action*. Basic Books.

Schrage, M. (2013) ‘Crafting Interactions: The Purpose and Practice of Serious Play’, in Valentine, L. (ed.) *Prototype: Design and Craft in the 21st Century*. Bloomsbury, pp. 19–28.

Smith, A. (1976) *An Inquiry into the Nature and Cause of the Wealth of Nations*. The Glasgo. Edited by R. H. Campbell and A. S. Skinner. Oxford University Press. Available at: https://www.ibiblio.org/ml/libri/s/SmithA_WealthNations_p.pdf.

Sviridova, A. *et al.* (2021) ‘The Role of Auditory Description in Comprehension of Demonstrators: A Pilot Study’, *Lecture Notes in Networks and Systems*, 276, pp. 530–538. doi: 10.1007/978-3-030-80094-9_63.

Tamsin, M. and Bach, C. (2014) ‘The Design of Medical Devices’, *International Journal of Innovation and Scientific Research*, 1(2), pp. 127–134.

Toffler, A. (1987) *Future Shock*. Bantam.

Walsh, V. and Roy, R. (1985) *The designer as ‘gatekeeper’ in manufacturing industry*.

Wang, N. and Xia, L. (2019) ‘Human-exhibition interaction (HEI) in designing exhibitions: A systematic literature review’, *International Journal of Hospitality Management*, 77(August 2018), pp. 292–302. doi: 10.1016/j.ijhm.2018.07.009.