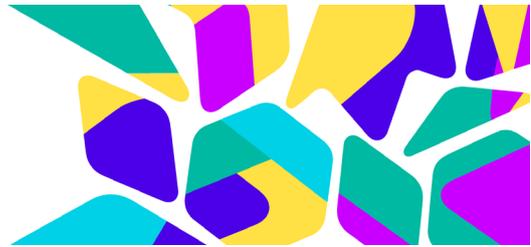


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# A pilot study used to better construct a research direction to understand where industrial design fits within the 4th industrial revolution (Industry 4.0)

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**Abstract:** The industrial design profession is engaging with a new manufacturing revolution — Industry4.0 (I4.0). This new paradigm presents new opportunities and challenges for industrial designers. However, it is still unclear what knowledge industrial designers can contribute to manufacturers in an emerging I4.0 context. This pilot study serves to determine the current state of practice of industrial design, and to discover areas of improvement as well as strengths to build on. Most importantly, this study functions as the first step to better qualify questions for a subsequent online questionnaire survey, in conjunction with findings from literature. A focus group was conducted with an even ratio of males to females (n=6) of industrial designers and identified current and future problems and opportunities for industrial design practice and its preparedness for I4.0. The findings suggest poor communication between industrial design and industry, as well as confusion around what I4.0 entails and how to contribute.

**Keywords:** industrial design; industry 4.0; design practice; qualitative

## 1. Introduction

Industrial design is the profession of design concerned with the design of mass-manufactured consumer products (Britannica-Academic, 2018). Its origins lay in the beginning of the 1800's during the First Industrial Revolution. With the shift from workshop to factory (Hauffe, 1998) the design profession became removed from the physical labour (craft) and thus a mental labour through the advent of mechanisation and mass production (Walker, 1989). Industrial design was therefore an integral and logical consequence of the developments in science, technology and large-scale mechanisation in production during that time (Conway, 1995). The shift from handmade to machine made thus opened new niches for occupations that industrial design utilised. Although the profession of the industrial designer was not officially coined until the 1960's (Moody, 1980), it was practiced long before that. Humans engaged in



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design activities since the advent of humanity (Barnwell, 2011). One crucial thing that sets humans apart from animals is the use and creation of technology (Toth and Schick, 2015), and now — more than ever — the technology we created is changing us.

Over two centuries later, industrial design is living through the 4th Industrial Revolution (Industry 4.0), which is a relatively new term coined to describe the concept of the smart factory or smart manufacturing (Petrelli, 2017). Even though industrial design is its own profession and is closely linked to manufacturing, both areas depend on each other. Hence, changes in each field influence the other. The advances and changes in science and technology created the industrial design profession in the beginning, and now, industrial design needs to adjust to these changes this new manufacturing paradigm (I4.0) presents. In brief: manufacturing is changing which is driving industrial design to change and adapt too.

Due to these rapid changes happening in the manufacturing sector, it is still unclear what is required for industrial design to evolve to stay relevant in I4.0. This led to the two research questions deduced from the literature:

1. What are concrete requisites of industrial design and Design for Manufacture (DFM), which ensure they are appropriate and relevant in adding value to manufacturing?
2. How does the industrial design profession have to change and adapt to stay relevant in the future manufacturing environment (I4.0)?

Both industrial designers and manufacturing industries depend on each other, and the collaboration of both parties is vital for the success of businesses and start-ups. Equally important is the consideration of new manufacturing technologies into design practice. Including new technologies, such as additive manufacture, Artificial Intelligence (AI), Virtual Reality (VR) etc., this enables industrial designers to be a proactive part in the creation of innovative products and systems/services. To conclude: in the words of Heskett (2001, P.25-26), “Should designers fail to adapt, new competencies will emerge to fill the gap left behind. The evidence of history is that design, as a basic human ability, is constantly required to adapt and redefine itself to meet the needs of its time. We should expect no less for our age.” García Ferrari (2017, P.S2631) elaborates that the design discipline — not unlike in the 20th century when confronted with crisis, such as I4.0 — “has the possibility of embracing a process of change and mutate again”. Therefore, industrial design is in a state of continuous flux and its evolution inevitable.

## **2. Study Aim**

The aim of this study is to determine the current state of practice of industrial designers and to explore areas for improvement and strengths to build on. I4.0 is predicted to change the way we manufacture and design products and collaborate. This pilot study serves as an immediate instrument to determine the current state of industrial design. The focus group is thus the initial step in designing a subsequent questionnaire, targeting a higher quantity

of industrial designers worldwide to gain a better understanding where the profession is lacking competencies and to iterate on opportunities emerging from the data. Moreover, this pilot study serves as an exemplar to educate other researchers in the design-specific fields on the use of the focus group method to develop questions for subsequent large-scale questionnaire survey (van Teijlingen and Hundley, 2001).

### **3. Method**

#### *3.1 A Focus Group as a Pilot Study*

The focus group was conducted at a prominent design school in Melbourne, Australia by all authors involved and included 3 female industrial designers and 3 male industrial designers, all with at least 2 years of experience.

A structured approach was important since the topic is relatively unexplored (Hesse-Biber, 2017) and the results of the pilot study thus helped to design the following quantitative questionnaire survey (van Teijlingen and Hundley, 2001, Puchta and Potter, 2004). This focus group study is a non-self-contained pilot study, serving in the initial exploration phase (Puchta and Potter, 2004) to answer the research questions generated from an extensive literature review on this topic. This method was mainly used to identify issues within the industrial design practice when working with manufacturers and industry. The extensive online questionnaire survey will help to further clarify these issues identified and find areas of improvement for the industrial design profession.

Conducting a focus group as the first methodological approach for this research, instead of in-depth interviews or other relevant methods, presented itself as an appropriate tool for this pilot study, since it offers a richer and deeper range of data through group dynamics taking place in a social environment (Breen, 2006, Rabiee, 2007). Further advantages include the time-efficiency in collection of big quantities of qualitative data with few participants (Breen, 2006, Hesse-Biber, 2017). Furthermore, focus groups are especially useful as part of a mixed method study (Hesse-Biber, 2017).

Further reasons for using a pilot study before conducting an extensive survey is assessing the feasibility of a full-scale study/survey, as well as the collection of preliminary data (van Teijlingen and Hundley, 2001, P.2). Concluding, according to van Teijlingen and Hundley (2001, P.3): “pilot study procedures can serve to improve the internal validity of questionnaires”. This was achieved by asking participants for feedback to find difficult and vague questions, as well as omitting unnecessary questions in regard to the research questions (van Teijlingen and Hundley, 2001).

#### *3.2 Coding and Analysis*

The qualitative data analysis software (QDAS) NVIVO was used to identify reoccurring and popular themes. Thematic Analysis (TA) was used to “systematically identifying, organising and offering insight into patterns of meaning (themes) across a data set” (Braun and Clarke,

2012, P.57). Since qualitative methods are after meaning (Hesse-Biber, 2017), TA allows making sense of “collective or shared meanings and experiences” across a data set (Braun and Clarke, 2012, P.57). Multiple patterns of meaning and experiences were identified and showed relations in the data set (Braun and Clarke, 2012). These patterns and relations were identified and mapped out to show the connections between themes visually. This was important to make sense of commonalities. The data set consists of an audio recording (1h 30min) which was later transcribed, as well as photos of the participant-organised Post-It-Notes. The data was imported into NVIVO which served as the QDAS.

The TA was conducted in 6 steps according to Braun and Clarke (2006, P.87):

1. Data familiarising
2. Initial code generation
3. Theme identification
4. Theme review
5. Theme defining/naming
6. Report findings

### *3.3 Structure and Approach*

The focus group was structured to ask initial questions followed by a brief explanation of the methods and an introduction to I4.0. These initial questions were all formulated from an extensive literature review conducted as part of a larger study but was subsequently used to inform this research. The following questions were discussed and individually written on Post-It-Notes and later pinned up and organised by each participant (Figure 1).

1. Q: What does design mean to you?
2. Q: What is industrial design and what does it mean to you?
3. Q: What are the strengths of industrial design?
4. Q: What are weaknesses of industrial design?
5. Q: What do you think the future of industrial design looks like?
6. Information and background: Research
7. Discussion and Post-It-Note pin-ups
  - a. What are issues or challenges you encounter during everyday working life in regard to manufacturers and manufacturing?
  - b. What are demands from manufacturers you cannot fulfil?
  - c. What are your demands for manufacturers they cannot fulfil?
  - d. Are there any things you want to know or understand better about manufacturing and your place in new product development?
  - e. What information gathered from industrial designers would help you being better prepared for the future in your profession?
  - f. What information gathered from manufacturers would help you being better prepared for the future in your profession?
8. Organisation of the topics and themes (Post-It-Notes)

9. Thoughts and feedback?

4. Results

The thematic analysis identified 5 main themes – Communication, Society Ethics & Norms, Capabilities (manufacturing limitations), Change and Industry 4.0. These themes are explained in detail below:

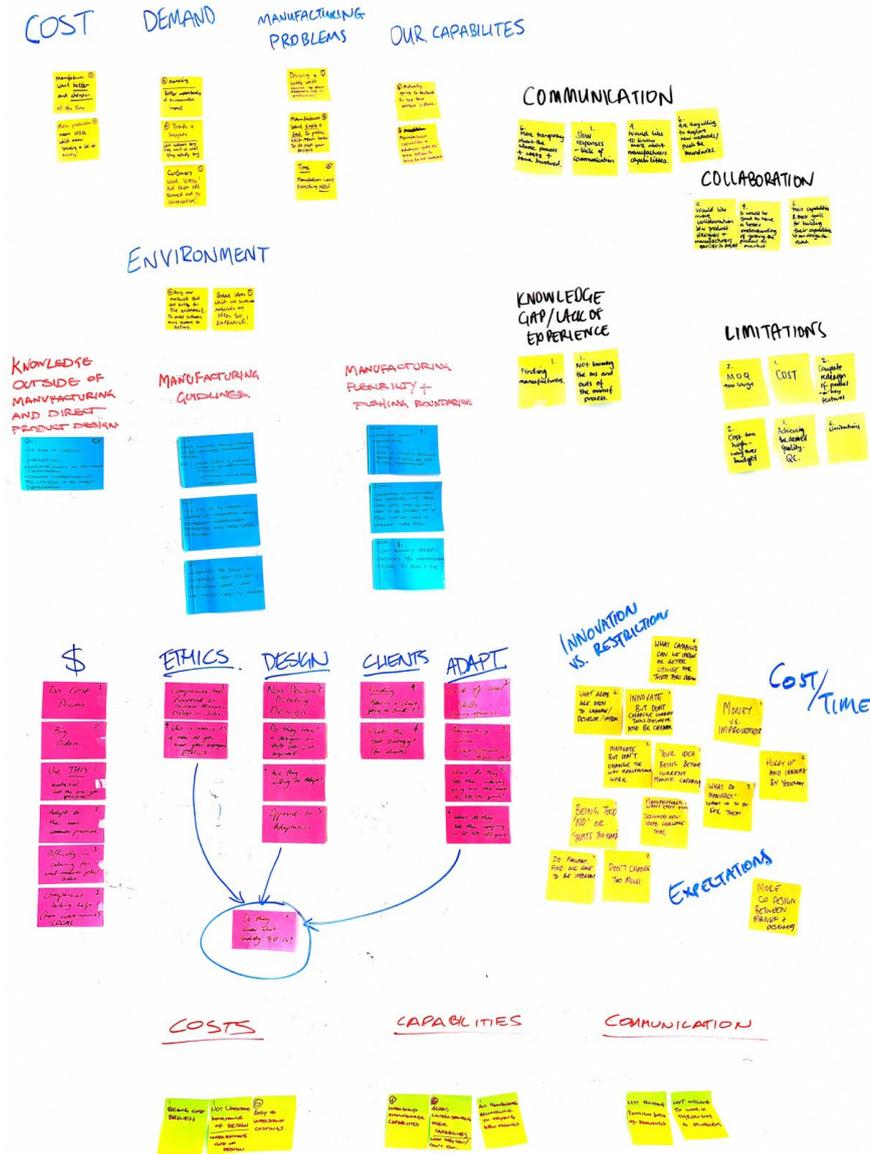


Figure 1 Focus group Post-It-Notes organised by participants after the focus group discussion

4.1 Communication

The thematic analysis showed the constant occurrence of miscommunication between

industrial designers and manufacturers. For this study it was found that industrial designers do not fully understand the current practices manufacturers employ and it suggests, that the manufacturing industry does not fully understand industrial design. This may be caused by the lack of transparency of certain manufacturing processes and stubbornness to collaborate on projects. In addition, the capabilities of manufacturers are largely miscommunicated — if even at all discussed. The industrial designers reported the constant issue of miscommunication in regard to the machines and processes involved in the manufacture of a given product. Industrial designers felt that their production capabilities were some sort of ‘black box’, where industrial designers are not aware what is happening inside.

The data suggests a conflict of interest through different understandings of meaning, as well as language barriers, especially with foreign industry partners (e.g. through aggregators such as Alibaba). Another interesting aspect is, that industrial design as a profession, and its capabilities are largely misunderstood by manufacturers with the resulting demands are often too high. A further cause of conflict is the expectation of manufacturers to constantly innovate, but without the will to adapt and make change towards their practice and capabilities. This could be largely attributed to risk-versus-reward, however with a lack of design intervention, certain manufacturers could cease to exist. The industrial designers within this focus group felt a general opposition from industry about trying new methods of production keeping their demands towards designers high. Other issues arose through having distinct priorities; whereas industrial designers are concerned with the end product and how the market and its users perceive it — manufacturers interest lie mainly in efficiency, cost and time savings during production. Most of the time, that means that industrial designers have to adapt to the manufacturer’s common practices and have to work within the dictated boundaries.

#### *4.2 Society Ethics & Norms*

The second main theme identified where the social and ethical implications were associated with design and manufacture. This includes female representation and communication between people within an office. Industrial designers have a social responsibility to create products which are empathic and mirror different social and cultural values for different clients. Furthermore, the participants emphasised the importance of the worker’s wellbeing in manufacturing-dominant countries such as China and India, as well as the responsibility of manufacturing processes which links to the sustainability of materials, the actual design of product and product life cycles. Industrial designers described the feeling of being indirectly responsible for the exploitation of labourers and their working conditions in foreign countries. The missing transparency of manufacturers — especially overseas — makes it hard to determine ethical manufacturing of products.

Yet the societal demand for production and consumption continue to drive new product development so there will always be a compromise between sustainability/socially responsible design versus profit and consumer demands.

Another concern expressed by the industrial designers within the focus group was sustainability in product design and the inability to control the use of materials, as well as manufacturing processes. Industrial designers felt disappointment about their profession through missing environmental regulations and the disregard of industry to see the sustainable aspects of the manufactured products. Industrial designers — although removed from manufacture — feel responsible for their designs and are often powerless against the choices of their clients and partners. Sometimes, they feel either misunderstood or not even heard. It can be suggested that industrial designers want to have a greater influence over manufacturing and its processes to have a stronger influence around the ethicality of what is being produced.

### *4.3 Capabilities (Manufacturing Limitations)*

Participants felt manufacturers were far too cost driven and thus hindering innovation on a product design level. One participant stated: “money versus improvement” still plays a huge role for industry today. Therefore, the resilience of industry to adapt and integrate changes into their practice is also an enormous limiting factor in the collaboration of both fields. Additionally — according to the participants — manufacturers do not fully seem to understand the importance of new product development. Participants felt frustrated by the expectations set by manufacturers since there is a discrepancy between the priorities of both professions. Whereas manufacturers favour efficiency and cost savings, industrial designers focus is with the design of products appropriate for customers and the market. Interestingly, industry expects industrial designers to “innovate by yesterday”, but at the same time anticipate to only utilise current manufacturing processes and technologies. Achieving innovation as well as saving costs, the resilience to adapt to changes and incorporating new processes stand in direct conflict with the manufacturer’s priorities. Manufacturers seem to be open to innovation, however, feel intimidated by design proposals brought forward from industrial designers.

### *4.4 Change*

There seems to be a big resilience from manufacturers towards change, which includes the adaptation of new technologies and innovative processes. Industrial designers are willing to push the boundaries whereas manufacturers want to keep traditions and current systems in place since the perceived risk is too high. This, in turn, influences the responsiveness and quality of collaboration in between manufacturing and industrial design. The expectations of industrial designers are therefore high, and it is assumed they have to work around these limitations. However, the authors of this paper tend to disagree with these findings as there are many examples within manufacturing where true innovation occurs, and where an industrial designer’s ability is prioritised. It is, however, a small sample and fulfils the purpose of this study by substantiating questions that lead to a much greater study. If the opinions of a small sample of industrial designers suggest there is a disconnect between industrial design and manufacturing, then this needs to be questioned. The main finding of

this section suggests a poor or even missing communication between manufacturers and industrial designers, which will also be explored in the subsequent online questionnaire survey. The participants felt that the manufacturers often show resilience towards trying out new ideas which conflicted with their own demand to industrial designers to innovate in the product design process. This incoherence leads to misunderstandings or even conflict during collaboration and often resulted in suboptimal product outcomes.

#### *4.5 Industry 4.0*

The most important finding of this focus group was that industrial designers are largely unaware or divided about what I4.0 means. This presents a huge opportunity for further research, as “design is the first step in manufacturing” (Boothroyd, 1994, P.505). Understanding I4.0 is vital for industrial designers to become a valuable and integral part of this new manufacturing revolution. Participants described I4.0 as a “buzzword” with its creation occurring somewhat “not organically” and felt a bit “forced” upon them. Consensus from participants was that new technologies in the industry drive new innovations and developments and open up opportunities in the design field. They noted the importance of being aware of I4.0, but failed to understand exactly where industrial design fits. This is the core aim of an extended study to better understand the role of industrial design in I4.0.

To summarise this section, discussion topics were generated based on the research questions asked during the focus group. The given answers, and identified themes gained through the conduction of this focus group serve as a base to design the subsequent online questionnaire survey. The research thus follows a structured approach in conducting and designing a rigorous mixed methods study.

### **5. Discussion**

The findings of this study will help better prepare industrial designers for the future manufacturing environment — I4.0. It has been found that design professionals still feel largely misunderstood by manufacturing and the effort and cost involved in new product development is constantly underestimated. This may be due to the lack of knowledge and miscommunications between industrial design and manufacturing during collaboration. Therefore, both manufacturers and industrial designers need to communicate their priorities and capabilities better to enable mutually beneficial collaboration. Another important aspect of this study is that the industrial design participants suggested they felt socially responsible and would like a larger influence over the choice of materials and manufacturing processes. The authors of this paper see these areas as key attributes of a good industrial designer. While there is a clear disconnect between manufacturing and industrial design in terms of communication and awareness of each other’s profession, they are both fundamentally inherent with each other. It is the responsibility of the industrial designer to understand materials and their manufacturing processes and ‘push’ manufacturers to accomplish the desired outcome without jeopardising the design intent. This is not always possible due to

costs, capabilities and expertise available; however, a good industrial designer must design products that are feasible to manufacture without being fixated on 'known' manufacturing processes. They must stay abreast with modern manufacturing processes – This is particularly important in the context of I4.0, where new manufacturing techniques will evolve that will directly benefit industrial design.

Another finding of this study was the lack of understanding of the term Industry 4.0. They felt that the word and its meaning need to be further clarified and multiple sources such as Schwab (2016) described Industry 4.0 in very different ways. This presents an opportunity for future research and how to educate design professionals about the changes happening in the manufacturing sector. It is vital that future research focuses on the exploration of how well industrial design professionals are prepared for the changes I4.0 brings. These include the integration of novel technologies and systems into industrial design-routine.

As discussed within this paper, the pilot study focus group was conducted to substantiate the questions for the subsequent online questionnaire survey. These are questions where relevant literature couldn't answer (either outdated or none existent) and are used to better understand where industrial design fits within a I4.0 manufacturing context. The questions derived from this research are as follows:

1. Do you feel like the profession of industrial designer is misunderstood or confused by the public or non-designers?
2. Rank your top 6 strengths of industrial designers.
3. Who benefits most from your abilities as an industrial designer?
4. Do you feel yourself rather included or excluded in the manufacturing process?
5. Give one example how you achieve innovation and creativity in product design when working with manufacturers or industry.
6. How prepared do you feel for the changes happening in the manufacturing sector?
7. How prepared do you feel your company is for the changes happening in the manufacturing sector?
8. What changes would you wish to see being implemented in the industrial design practice in the future?
9. Do you see a role for industrial designers in the future of manufacturing?
10. Do you know what Industry 4.0 is? If yes: Please explain in your own words.

The first question (Q1) is based on the constant occurring miscommunication between industrial designers and manufacturing/non-designers. The results will give clarity if the perception of industrial design differs in different countries and regions. Q2 expands the first question by clarifying the self-perceived strengths of industrial designers, which will assist manufacturers and industry in understanding the services they provide, as well as their capabilities in product development. Knowing this is important due to the persistent confusion of the industrial design profession seen within literature and within the focus group when linked to manufacturing. Q3 adds to Q2 and aims to find answers of who

industrial designers prioritise in their practice. Q4's purpose is to validate if industrial designers worldwide share the same view towards manufacturers like the Australian focus group participants did. Q5 builds on the strengths of industrial designers and how manufacturers can benefit from innovation created through design. Since it is still unclear what is required for industrial design professionals to be a valuable part of I4.0; Q6/Q7 will elucidate this question without mentioning I4.0 directly. Q8 elaborates on the perspective of industrial designers and their view on self-implemented interventions in the future of their profession. Since there are large changes taking place in the manufacturing sector — with the concept and implementation of I4.0 — industrial designer's input is largely ignored. Thus, the question (Q9) participants raised in the focus group around whether or not manufacturers and industry value industrial designers as an integral part of their industry will be asked. Finally, considering the divisive nature of the term — I4.0 and the changes this paradigm will present to industrial designers — Q10's objective is to gain insight into how many industrial designers worldwide are un/aware of I4.0 and how understandings or definitions differ from designer to designer (or company to company). Targeting these questions to a bigger audience will validate and/or disprove the findings of this focus group study, and therefore give a solid base to find answers to the two research questions. Because the survey questions are both quantitative and qualitative in nature, they will provide a variety of useful information about the current state of industrial design and what changes have to be fulfilled to continue be a valuable asset for manufacturers and industry in the future.

## 6. Conclusion

The focus group that was conducted as part of our study served as the first step of a mixed methods study to determine the current state of the industrial design practice, as well as finding areas for improvement — especially in collaboration and communication with manufacturers. The main finding of this study was the poor, or even missing communication, between the manufacturing industry and industrial designers. However — most importantly — finding out about the confusion surrounding I4.0 in relation to industrial design presents an opportunity for further research, which aims to empower the importance — and adaptation — of industrial design in the next industrial revolution. Since new questions arose from this pilot study, it helped to design the subsequent online questionnaire survey which aims to further elaborate on new findings relevant to the research questions. The focus group method, as a pilot study, thus served to bridge the gap between the literature and the major questionnaire survey to continually advance the industrial design professional — keeping it relevant and on par with the advancements of manufacturing.

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